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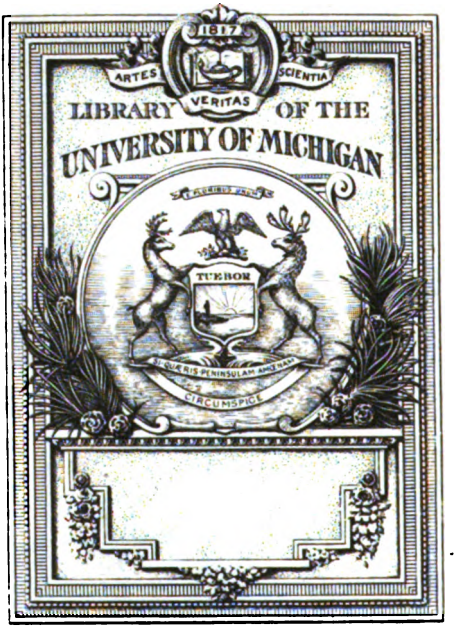

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PROCEEDINGS

OF THE

GEOLOGICAL

AND

POLYTECHNIC SOCIETY

OF THE

WEST RIDING OF YORKSHIRE.

1842—48.

VOLUME II.

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE EIGHTEENTH QUARTERLY MEETING, HELD AT WAKEFIELD, ON MONDAY, 4TH OF JULY, 1842.

On the motion of HENRY BRIGGS, Esq., seconded by THOMAS WILSON, Esq.,

WILLIAM WEST, Esq. was called to the Chair.

Mr. WEST said it would have been more agreeable to him if some one else had been elected president, but as he had wished well to the Society from its commencement, he thought he could not better show that good will than by complying with their wish. He was sorry to see such a small attendance, but he thought the circumstance could be well accounted for. The unfavourable weather had, he knew, detained some in Leeds; and some had only just left a long and laborious, though, he must add, an interesting meeting of the British Association, at Manchester. He trusted, however, that when they next met it would be in greater force. He hoped that the character of the Papers which would that day be read, would increase the number of the Society's members.

The following gentlemen were elected Members of the Society:—

Rev. WYNDHAM MADDEN, M.A., Woodhouse, Huddersfield.
Rev. C. ALDERSON, M.A., Kirkheaton, Huddersfield.
THOMAS FIRTH, Esq., Toothill, Huddersfield.
THOMAS MASON, Esq., Copt Hewick, near Ripon.

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The following resolution was then passed, on the motion of Mr. BRAKENRIDGE, seconded by Mr. HARTOP:—

That the thanks of the Society be given to the Directors of the Proprietary School, for the use of their Hall.

The Secretary reported that Mr. Hartop and himself had attended the meeting of the British Association in Manchester, as representatives of this Society, and said, that according to the arrangements made at Sheffield, this meeting was appointed to be held on the Monday succeeding the close of the sittings at Manchester, in the expectation that some of the geologists who were there would attend; but he regretted to say, that owing to the Installation of the Duke of Northumberland taking place this day, Dr. Buckland, who had signified his intention to be present, had been obliged to leave Manchester on Saturday, and the same circumstance had called Professor Sedgwick away at a still earlier day.

The CHAIRMAN, in alluding to the subject of the meeting of the British Association at Manchester, said that the next meeting of that body would be held at Cork, in Ireland. They had very narrowly missed having it at York, in accordance with an invitation that had been sent from that city. He would take this opportunity of saying, that if the members of the Geological Society wished to have the meeting of the British Association held in Yorkshire in 1844, they ought to attend the meeting in 1843, and give an invitation.

The following Paper was then read:—

ON THE RELATIVE PROPERTIES OF IRON, MADE BY THE USE OF COLD AND HOT AIR BLAST IN THE SMELTING FURNACE.—BY HENRY HARTOP, ESQ., OF BARNBOROUGH HALL, NEAR DONCASTER.

In the early part of the year 1829, the use of hot air in the smelting furnace, for the manufacture of cast iron, was

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introduced at the Clyde Iron Works, near Glasgow; and at the fourth meeting of the British Association, held at Edinburgh in 1834, Dr. Clark gave an account of its success as follows:—

"That in their previous operations with cold air, 8 tons "1 cwt. 1 qr. of splint coal (made into coke, at a loss in "weight of fifty-five per cent.), was required to make 1 ton "of iron.

"With the use of air heated to about 300° Fahrenheit, "5 tons 3 cwt. 1 quarter of coal (in coke) produced a ton of "iron, in addition to which, 8 cwt. of coals were used for "heating the air.

"In 1833, the temperature of the air used being 600° "Fahrenheit, it was found that raw coal (not coked) might "be used, which circumstance further reduced the quantity "of coal required in the furnace to 2 tons 5 cwt. 1 qr. per "ton of iron made."

Not having been present at Edinburgh, on the Association's meeting the following year in Dublin, I stated that the case had not been correctly represented to Dr. Clark,*

* A similar misrepresentation has also been made to Mr. Mushet, by reason of which he has been led into an error so far as to state, in his most valuable work on iron and steel, pages 222-223, that the materials used at the Milton Works in December, 1834, with cold blast, were for each ton of iron made,—

	Tons.	Cwts.	Lbs.
Coals	6	3	2
Ironstone	4	1	0
Limestone	0	13	0

At the same works, in December 1836, with hot blast,—

	Tons.	Cwts.	Qrs.	Lbs.
Coals per ton of iron in the furnace	2	4	3	14
Ironstone	3	11	2	21
Iron Ore	0	0	1	0
Limestone	0	16	0	14

It is, however, well known, that on an average of the year through, previous to April 1829, when cold blast was used at the Milton Works, the materials consumed were—

	Tons.	Cwts.	Qrs.	Lbs.	
Coals in the furnace	4	18	0	0	per ton
Ironstone ditto	3	14	3	9	of iron
Limestone ditto	0	14	3	29	made.

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inasmuch as for some time previous to 1825, a saving in the coking operation had been made at every well-conducted iron work, by which a ton of iron could be make with 5 tons of splint coal in the furnace, when cold blast was used; so that in reality a saving only took place (by increasing the temperature of the air, so far as to enable them to use coal uncoked in the smelting furnace) of 2 tons 5 cwt., that is, from 5 tons to 2 tons 15 cwt.

The account, therefore, as regards economy, by the use of hot air, will stand thus:—

	Tons.	*Cwts.*	*s.*	*d.*	£.	*s.*	*d.*
Saving in coal used in the furnace	2	5	5	0	0	11	3
In Coker's Wages					0	2	3
					£0	13	6
Against this may be set down—							
A greater quantity of ironstone used per ton of iron made	0	3	8	6	0	1	3
Extra wear on ditto.....					0	3	6
Coal to heat the air used	0	8	2	0	0	0	10
					£0	5	7
Saving in materials by the use of hot air, per ton of iron					0	7	11

To which saving may be added a further sum of 4s. 7d. per ton, for the greater quantity of iron produced from each furnace, when hot air and coals are used, making the total saving of 12s. 6d. per ton of pig iron.

But in 1835 the deterioration in the value of iron so made was about 17s. 6d. per ton, as I stated at Dublin, and at the present time, (March, 1842) I have no recantation to read so far as the above observations go.

And in comparing this with the make by hot air, in December, 1836, (one of the best months in the year for iron making), an addition of 8 cwt. of coal being made for heating the air, the difference is truly so small as to be altogether unworthy of consideration, on taking into account the deteriorated value of the produce.

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In Dublin, my observation that the deteriorated value of hot blast iron in the market was 17s. 6d. per ton was contradicted; but after seven more years of unceasing application, practised in the manufacture on a very large scale, of numerous experiments by indefatigable practical men of great ability, of the attention of learned Professors of chemistry, mineralogy, and geology, together with the aid of that no inconsiderable engine, the public press, the price of pig iron so made is 32s. 6d. per ton below that made by cold blast in the smelting furnaces.*

If you ask why iron so made is sold for 32s. 6d. less in the market, the answer is—1st, its great weakness under *impact*, and therefore its total unfitness for most purposes in which the greatest weight of iron is used;† 2nd, its greater loss in remelting in the cupola of 2 cwt. per ton; 3rd, the great irregularity in the contraction of castings when cooling, if made from hot blast iron, on which account many castings of different sizes are produced from the same pattern, causing great expense in their after fitting, or, if this expense is not

* March, 1842:—

	Per Ton.
Price of Scotch hot blast iron at Hull, (No. 1.)	£3 7 6
To which add for its general inferiority to Yorkshire iron when both were made from cold blast	0 5 0
	£3 12 6
Price of Yorkshire cold blast iron at Hull, (No. 1.)	5 5 0
Difference in favour of cold blast iron generally	£1 12 6

† In Mr. Fairbairn's recent experiments, published in the Manchester Memoirs, the difference in this respect is very striking:—

Each bar being 1 inch square and 4 feet 6 inches long between, supports—

	Breaking weight.	*Power to resist impact.*
Oldberry cold blast iron	458 lbs.	822 lbs.
Oldberry hot ditto	543	549
Using the same coal and ironstone—		
Elsecar cold ditto.....	446	992
Milton hot ditto	353	538
Working in the same mineral field in N. Wales—		
Ponkey cold ditto.....	567	992
Plaskynaston hot ditto	378	517

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incurred, great defect in all machinery, &c. &c. so made; 4th, its unsoundness, when made into castings that require to be turned, bored, or planed, &c.; on which occasions, if the surface operated upon is not defective on its entire area, a defect so considerable will show itself, probably when nearly finished, that both the casting and the great expense bestowed upon it will be thrown away, and in many such cases the expense of making the casting itself will be at least three times greater than even the present great difference in the value of the two kinds of iron.

I need not unnecessarily occupy your time further than by going more fully into the first of these points,—the great weakness, under impact, of hot blast iron.

My attention was first called to the subject by observing great quantities of pig iron, on the wharfs at the iron foundries and other places in this neighbourhood, very recently broken into pieces so short as to prevent the labourer piling them in cubical tiers in the usual manner; and on inquiry, I found that they were so broken by loading and reloading, and that they were made by the new process of using hot air in the furnace, greatly miscalled an improvement in the manufacture of cast iron. From these and other circumstances, I thought it a duty due to the iron trade to call the attention of the public to it, and having mentioned the subject at the meeting of the British Association in Dublin, its importance was at once recognised, and a sum of money appropriated for making the needful experiments, which were carried into execution by Mr. Fairbairn, the highly intelligent and indefatigable engineer of Manchester. I was very sorry to find from his report read at the Liverpool meeting, as well as from several conversations which he had with me on the subject, that he had experienced great difficulty in ascertaining the composition of the irons experimented upon, in consequence of many of the manufacturers being unwilling to give information: and

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when I add to this, that in more recent experiments, one of the strongest irons in Yorkshire has been placed in the scale of strength much below another iron, well known to be no stronger, (both irons being made from the same coal and ironstone, a fence only parting the mineral fields of each work,) I am driven to the conclusion that the object of the experiments in question has in a great measure been defeated. There are, however, some experiments in them, which may not have been affected in their results by these circumstances, two of which I shall point out to your consideration.

The first will be that of iron from two works using the same materials.

Elsecar iron (cold-blast) mean ratio of its strength...	1000
Milton iron (hot blast) mean ratio of its strength ...	809
Elsecar iron, mean ratio of power to resist impact ...	1000
Milton ditto ditto ditto ...	858

In this case the difference is really much greater than appears on the face of these experiments, inasmuch as the specimens of pig iron from the Milton Works were made with the addition of a portion of the red hematite iron ore from Ulverstone, for the express purpose of giving greater strength to that iron, as was invariably done many years for the purpose of making tin plate, and during the war for the casting of cannon.

The second circumstance is that where Mr. Fairbairn reports on a trial of fifty sorts of iron, of which each bar* of hot and cold blast iron was made of the same materials, and under the same circumstances.

Cold blast iron, with a load of 392 lbs. increased the deflection in 108 days from 1.786 to 1.843 inches.
Hot blast iron ditto... 1.891 to 1.966 ditto.

* I take this to mean each pair of bars.

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Cold blast iron, with a load of 448 lbs., continued to increase in deflection, and ultimately broke, after sustaining the weight 35 days.

All the hot blast iron bars broke in the act of loading them with the above weight of 448 *lbs.*

Notwithstanding these and many similar facts brought out by the experiments in question, certain portions of them are constantly being quoted for the purpose of proving that iron made by hot air is stronger than that produced by the use of cold air.

Contemporary with these experiments on a small scale, others of far greater importance have been going on; thus we hear of hundreds of railway chairs, cast from iron made by the improved process, constantly breaking, where tens only broke before;† of steam engines and other valuable machinery breaking in rapid succession, and in parts where, by regular work, they were never known to give way before the introduction of the improved iron; of the more respectable portion of millwrights being obliged to make new calculations, and a new stock of patterns, in order to lessen, as far as is in their power, the enormous losses and the great disappointment of their friends by such breakages. We hear of coal-masters of whole districts, and other prudent and humane proprietors of large establishments, introducing clauses in their contracts for castings, stipulating that no hot blast iron shall be used therein; and at length the same has become common in contracts for gas and other pipes, which it has hitherto been usual to make of the most inferior quality of irons, it having been found that the sockets of some miles of piping have

† In a paper recently read before the Institution of Civil Engineers, Mr. Macneill states that on the Dublin and Drogheda Railway, where chairs were used made of hot blast iron from Scotland, the breakage was very great, as compared with those on the South Eastern Railway, where they were made of cold blast iron, and that, in his opinion, the latter would be cheaper than the former at an increased price of £4 per ton.

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been broken off in one or two years after they were laid down, in consequence of their having been made of hot blast iron.

There has, also, still more recently, been a series of experiments made, upon which a far greater dependance may be placed, inasmuch as the irons were all supplied in the regular way of business, without the makers knowing any such experiments were intended; and they were undertaken for the purpose of information only, to guide the founder and engineer who conducted the operations at his own establishment. The detail of these valuable trials by Mr. Todd, of Leeds, formed a paper read before this Society when last it met at Leeds. I need not, therefore, occupy your time with repeating them here, and will only call your attention to a few of the results, for the purpose of more clearly explaining what I wish particularly to impress on your notice.*

With respect to the strength of bar iron made from hot blast pig iron, very few experiments have been made public that I am aware of; Mr. Todd's experiments are, therefore, of very great importance, because they were made with the greatest possible care, and regardless of expense, by manufacturers of the first eminence and ability for their private information. The irons were eight in number; the first set of bars were 2¼ inches in diameter, made with cold blast scraps and hot blast

* They took place from August, 1840, to February, 1841.

			Breaking weight.	
			Cwts.	*Qrs.*
Bierley pig iron, ...	No. 3, made with cold blast,	average	25	2
Elsecar do.	No. 3, do.	do.	24	0
Low Moor do.	No. 3, do.	do.	23	2
Summerlee (Scotch) do.	No. 3, hot blast,	do.	17	2
Level, Staffordshire do.	No. 3, do.	do.	16	0
Mixed do.	No. 3, 5 parts Low Moor, 1 part Elsecar	do.	30	0
Mixed do.	No. 3, 5 parts Bierley, 1 part Elsecar	do.	33	0
Mixed do.	No. 3, equal parts Bierley, Elsecar, Low Moor, Staffordshire, (Cylinder iron in the market,) and Level iron, also Summerlee	do.	20	2

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respectively, all by Yorkshire manufacturers. The weight required to draw them asunder by a steady direct tension was not very variable; but when all were cut round to the same depth, for the purpose of being broken with the hammer, they required about the following blows to do so:—

	Blows.
Cold blast iron	6
Scrap	3
Hot blast	1

The second and third set of bars you have now before you, the results of experiments on which stand thus:—

	Diam. of bar. in.	Area of sec. where cut.	Blows required to break them with a 17lb. hammer.
Low Moor, cold blast ...	2.66	3.976	18
Bierley, cold blast	2.75	4.430	18
Milton, hot blast	2.75	4.430	3
			Blows required to break them with a 20lb. hammer.
Elsecar, cold blast	2.58	3.976	21
Milton, hot blast	2.58	4.203	1½

Made from the same materials.

So that the proportionate resistance of hot blast wrought iron to *impact* is still less than that of cast iron. I need scarce say, that the result was that cold blast iron was ordered at probably £6 per ton more than the hot blast iron might have been bought for.

I may here take leave to mention the circumstance of scrap iron being anything now but what it was formerly, when its name was synonymous with excellent quality. In former times the importation of scraps from the Continent of Europe took place to a very considerable extent, all of which were manufactured in this country into bars, sheets, &c.; and from the circumstance of these scraps being all of charcoal iron, the bars, &c. so made could not but deserve the good name they acquired and long maintained. The flow of scraps into England has, however, long since ceased, and the exportation from this country having become a considerable trade, it

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follows, of course, that scrap iron now must be made from our own scraps; and when it is remembered how small a proportion of good iron has for many years been made here, bars, &c., manufactured from scraps, cannot but be of very irregular and dubious quality; hence it is that the best scrap iron cuts so poor a figure when compared with a well made iron from known good minerals.

The remarks I have made are in reference to irons of known good quality; but I am ready, and have pleasure in admitting that the use of hot air has been of very great advantage at those iron works whose produce had not a first-rate name, by enabling their proprietors to make it at a less cost, without a proportionate deterioration in quality; and there are some few works whose iron, made with cold blast, was so bad, that any change could not be but for the better. There is also at present a strong impression that iron cannot be made with anthracite coal only, without hot air, and that iron so made is better than any other. The goodness of its quality is, however, due to the great purity of that coal. But even here we are told, in a Paper read before the Polytechnic Society of Cornwall, by a gentleman of great practical skill, that iron made with such proportions of anthracite coal and coke as enabled him to use cold blast, became much weaker on his using hot air, all other circumstances being the same.

My apology for troubling you so far must be in the importance of the subject, and the daily increasing importance to society of the strength of that material by which the locomotive power is applied that so rapidly conveys a very large portion of the human race both by land and sea. When we are about to purchase a horse which is to convey ourselves and families at the moderate rate of eight or ten miles an hour, with what inherent caution our first object is to examine his knees, to ascertain his safety! In the steam-engine we are prevented taking this precaution; and yet in travelling

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three times as fast, our risk is in very much greater proportion. Now in this fast travelling it must not be forgot that in the engines which convey us there are two cylinders, and at least 280 returns of the piston, and therefore there are 280 percussions each minute of 9240lb. pressure in the power itself; there are also forty-two wheels and axles in each train passing over a joint of the rails every five yards of our journey, the percussions of which are very sensibly felt; with numberless others of minor effect, by which it will be at once seen of what inestimable importance it is that all iron used for such purposes should not only be strong, but be so under percussion; for I need only remind you that it is more than probable, should any one of the numerous parts give way, by any one of the many percussions they have to sustain, that an accident of the most calamitous nature would be the result.

With this view of the subject, I may probably be excused if I so far further trespass on your patience as at least to endeavour to point out a duty which the public only can perform for itself, namely, to take especial care that protection is given to that class of iron makers whose first aim is to maintain in its utmost strength the produce of their foundries, regardless of the expense of doing so. And in order that it may be understood how far such protection is required, the following statement should be made known. In the year 1830 the total quantity of pig iron made in Great Britain was about 653,500 tons. In 1840 the make had increased to 1,396,400 tons; and although the stock of pig iron at the latter date was very small, the price of No. 1 had declined since the use of hot air from £8 5s. in 1836, to £5 5s. per ton in 1842 for cold blast iron; and from £7 5s. to £3 12s. 6d. for hot blast iron,* although the workmen's wages throughout this period were

* I have been informed that No. 1 hot blast iron has been delivered in Leeds for £3 2s. 6d. per ton, the average of former years being £9 10s. per ton for No. 1 cold blast pig iron.

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rather higher, which item forms nearly 75 per cent. of the cost; from which circumstance it has been very fairly concluded, that the price of the best pig iron made has been brought down at least 30s. per ton lower than it would otherwise have been by the badness of trade generally, had not the use of hot air been introduced in its manufacture.

In addition to the observations I have already made on this subject, I may refer you to the price current of the present day, and you will see the price of cold blast pig iron in South Wales stand at £3 10s. per ton for No. 1; hot blast pig iron in the Clyde, £2 10s. per ton for No. 1; and, upon the whole, it seems this case may now be thus summed up,—

The saving in the make of pig iron by the use of hot blast may (generally speaking) be ...	£0	12	6	per ton.
Deteriorated value of such iron in the general market	1	0	0	do.
Deteriorated value in the Yorkshire district ...	1	12	6	do.
Deteriorated value of castings made of such iron, in the simple article of railway chairs, as reported to the Institution of Civil Engineers, on the 1st day of March last, by one of their own body, of the first eminence, and of very great experience in such matters ..	4	0	0	do.
Deteriorated value of wrought iron when manufactured from pig iron so made, in the market	6	0	0	do.

Indeed, in the last-named kind of iron, engineers and intelligent manufacturers are agreed, and the experiments I have before referred to show, that £6 per ton is far too low an estimate of its deterioration, and particularly when we reflect how very much bar (and other) iron has now to do with the personal safety of millions of our fellow creatures.

A desultory conversation followed the reading of the Paper, at the close of which, Mr. Morton said that he did not profess to understand the subject, but he would suggest that it should be brought forward and fairly discussed at another meeting of the Society. When they considered the

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importance of the manufacture of iron, he thought it was deserving of great consideration whether the use of the hot blast would effect the purposes of the cold blast at a cheaper rate. The quantity of iron manufactured in England is now double what it was some years ago. It had been said that the hot blast would produce double the quantity produced by the cold blast, but then they must consider whether the quality of the former, was equal to that of the latter. Mr. Hartop had said it was not. He did not consider that the tests used in these experiments were to be depended upon. For the force exercised by a man's arm was very variable; and it might be to the interest of the striker to make it so. If he were interested in the hot blast, the blow might be very weak, and if he were interested in the cold blast, it might be much heavier. He would suggest for the proper testing of this matter, that the bars of iron intended for experiment should be placed upon equal bearings, and that the weights should fall from the same elevation. If, therefore, the question of hot and cold blasts were to be discussed, the data must be more complete than those now before then. Formerly iron could only be made with charcoal, and it was then said that coke would not make iron of so good a quality; but coke is now used in great abundance, and has given employment to vast numbers of people. Hot and cold blasts might therefore be considered in the same relative position to each other, as were formerly charcoal and coke.

A Paper was then read

ON THE MOLECULAR CHANGE IN THE CONSTITUTION OF WROUGHT IRON FROM THE EFFECTS OF VIBRATION AND CONCUSSION.—BY RICHARD SOLLY, ESQ., OF SHEFFIELD.

Mr. SOLLY exhibited a portion of an iron pin, which afforded an instance of the crystallization of fibrous malleable iron by the effects of vibration. The iron, of which this pin

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was made, was originally of the strongest and toughest kind, and entirely fibrous. It had become granular and brittle by being subjected to great vibration at a temperature very considerably below that of boiling water. He was unable to exhibit a sample of the identical billet from which this broken pin was made, because Mr. William Lucas, who took it with him to Manchester, had given it to Sir Henry De la Beche, to be placed in the Museum of Economic Geology; but he had provided himself with a small specimen of similar tough iron for the purpose of comparison. The manufacture of the pins was then explained. Puddle bars were made from the best Shropshire and Staffordshire cold blast grey pig iron, piled seven high, ball-furnaced, shingled, and rolled into a billet, which was drawn down to the size required under a small forge hammer. The pins were used to hold down the brasses over the neck at the end of the long shaft which turns the little mill, and this shaft, as it revolves nearly 300 times per minute, experiences a violent vibration. When the mill was in action, the temperature of the pins was not above 100° of Fahrenheit, and they were in no part nearer to the point of friction than six inches. The cause of the pins not having attained a greater degree of heat, was on account of their distance from the nearest point of friction, and also from the brasses being well supplied with oil and grease. The pins had been in use for two or three months when they broke, and their breaking caused the breaking of a wheel, and also of the bed of the carriage at the end of the shaft. Mr. Solly said frequent cases of this kind had occurred at their iron works, at Tividale, in Staffordshire, particularly with the pins on which the shears work; the shears, being used for cutting bars of iron cold, are subjected to constant small shocks or jerks. He had lately had an opportunity of examining at the Railway Station, Derby, four broken axletrees, all of which presented a crystalline appearance. One of the

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gentlemen connected with the engineering department, to whom Mr. Solly suggested that the accident had been owing to the vibration of the wheels on the rails, said he attributed it solely to the original bad cold short quality of the iron. He mentioned this subject, as it might be of importance to the public, whose lives might be endangered by the liability of axletrees to break. The investigation of this question Mr. Solly considered as the peculiar province of a Polytechnic Society, and he hoped it would be by them taken up, as it had already attracted a great deal of attention. It was discussed in the Mechanical Section of the British Association, at Manchester, last week, and a grant of £150 was made for Mr. Fairbairn and a Committee to ascertain if any, and what changes take place in the internal constitution of metals when exposed to continual vibration and concussion, as in the case of the axles of locomotive engines. Messrs. Newall, the well known wire rope manufacturers, told Mr. Solly's brother last April, that they found not only that fibrous iron becomes granular by vibration, but that granular iron, by being constantly bent backwards and forwards, becomes fibrous. Mr. Solly concluded his remarks by saying, that the most useful object would be to find the remedy, and he understood it had been ascertained, that very careful annealing is indispensable for all iron axletrees.

Mr. Wilson then exhibited the head of a spear, which had been found twenty-four feet below the surface of the earth, in the valley of the Calder, near Fairies' Hill; and a piece of the rock of Gibraltar.

A vote of thanks was then passed to the Chairman, for his able services in the chair; and to Mr. Hartop and Mr. Solly for their papers.

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE FOURTH ANNUAL MEETING, HELD IN THE MUSIC SALOON, WAKEFIELD, ON WEDNESDAY, 7TH SEPTEMBER, 1842.

The Right Honourable the Earl FITZWILLIAM, the President, in the Chair.

The following gentlemen were unanimously elected Members of the Society:—

SAMUEL HAILSTONE, Esq., F.G.S., Bradford.
EDWARD HAILSTONE, Esq., F.S.A., Bradford.
JAMES MALLINSON, Esq., Brighouse.
E. B. WHEATLEY, Esq., Hopton.
D. MACINTOSH, Esq., Blair-gowrie, Perthshire.

The Secretary then read the following Report:—

REPORT OF THE COUNCIL OF THE GEOLOGICAL AND POLYTECHNIC SOCIETY OF THE WEST-RIDING OF YORKSHIRE, TO THE ANNUAL MEETING, 1842.

Since the last annual meeting, the proceedings of the Society have been generally satisfactory, though unmarked by any peculiar feature. There has not been much variation in the number of members; but the Council have pleasure in stating, that the loss which must inevitably take place from death and resignation, has been more than counterbalanced by the addition of new names to the list.

In September, 1841, the number of members reported was 326; since that time 33 have been elected, 5 have been removed by death, and 25 have resigned, making the present number 329.

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Owing to peculiar circumstances attendant upon this meeting, the Treasurer is unable to present a detailed account of the receipts and expenditure: it will, however, be immediately submitted to the Auditors, and printed in the forthcoming Report.

During the past year, the quarterly meetings have been held as follows: viz., in December, at Huddersfield; in March, at Sheffield; and in June, at Wakefield; at all of which communications of interest and importance have been read; many of them have been of great practical value, and afford an additional proof of the benefits resulting from a society of this nature, in a district where so large a population is dependent upon the successful prosecution of those arts which more immediately come under its cognizance. The titles of the papers are as under:—

At the annual meeting, in SEPTEMBER—"Illustrations of Yorkshire Geology," by the Rev. W. Thorp.—"An Elucidation of the Geometrical principles of Gothic Architecture, No. 2," by W. Wallen, Esq., F.S.A.—"On the preservation of Railway Sections, and of accounts of Borings, Sinkings, &c., in elucidation of the measures recently taken by the British Association," by Thos. Sopwith, Esq., F.G.S.

DECEMBER.—"Observations on the Yorkshire Drift and Gravel," by J. T. Clay, Esq.—"On the data for a comparison between the heat yielded by coke and by coal," by W. West, Esq.—"An Elucidation of the Geometrical principles of Gothic Architecture, No. 3," by W. Wallen, Esq., F.S.A.

MARCH.—"On the use of wire rope as a substitute for hempen rope, on railways and in mining," by Charles Morton, Esq.—"On Fossil Footsteps in the Carboniferous System," by Mr. W. Lee, Sheffield.—"On the evidence of the former existence of Glaciers in Great Britain," by Thos. Sopwith, Esq., F.G.S.

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JUNE.—"On the relative qualities of Iron made by the use of the Hot and Cold Air Blasts in the Smelting Furnace," by Henry Hartop, Esq.—"On the molecular change in the constitution of wrought iron, from the effects of vibration and concussion," by Richard Solly, Esq., Sheffield.

The Council report with much regret Mr. Wilson's resignation of the offices of Secretary and Treasurer, which he has most efficiently filled since the formation of the Society. To his zealous and indefatigable exertions, a great degree of the success which has attended its operations is attributable; and they can scarcely indulge in the hope, that the Society will be able to find a successor able and willing to devote the time and attention which he has so cheerfully given to its service.

The establishment of a Museum of geological specimens, and more particularly of those peculiar to this district, has always been considered of primary importance; and in order that the numerous specimens already contributed may be systematically arranged, the Council have engaged a resident curator for a temporary period, with a view of permanently continuing the appointment, if experience should render this course advisable. The Council request the continued co-operation of all those members who are enabled to afford assistance by the presentation of fossils, in the hope that some light may be thrown upon many disputed geological points, by a thorough acquaintance with the organic remains occurring in this coalfield.

Liberal contributions of local fossils are also valuable from their affording the means of effecting advantageous exchanges with other societies and individuals, by whom many offers of this nature have been made.

The Council have reason to believe that the Reports of the proceedings of the meetings are held in increased estimation; and they confidently hope that the continued and

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cordial co-operation of its Members will gain for the Society a still more extended support.

It was then moved by HENRY LEAH, Esq., seconded by WM. WEST, Esq., and carried unanimously:—

That the Report of the Council be received and printed.

WILLIAM WALLEN, Esq., moved, and THOMAS PITT, Esq., seconded the next resolution, which was carried unanimously:—

That the following noblemen and gentlemen be elected officers for the ensuing year:—

PRESIDENT.

EARL FITZWILLIAM, F.R.S.

VICE PRESIDENTS.

DUKE OF NORFOLK.	T. W. BEAUMONT, ESQ.
EARL OF EFFINGHAM.	J. S. STANHOPE, ESQ.
EARL OF DARTMOUTH.	R. O. GASCOIGNE, ESQ.
LORD WHARNCLIFFE.	G. LANE FOX, ESQ.
LORD STOURTON.	J. W. CHILDERS, ESQ., M.P.
VISCOUNT MILTON.	E. B. BEAUMONT, ESQ.
VISCOUNT HOWARD, M.P.	G. WENTWORTH, ESQ.
HON. W. S. LASCELLES, M.P.	W. BENNETT MARTIN, ESQ.
HON. J. S. WORTLEY, M.P.	C. J. BRANDLING, ESQ.
HON. G. W. FITZWILLIAM, M.P.	J. G. MARSHALL, ESQ.
SIR F. L. WOOD, BART.	MICHAEL ELLISON, ESQ.
SIR W. B. COOKE, BART.	T. D. BLAND, JUN., ESQ.
REV. W. SCORESBY, D.D. F.R.S.	P. D. COOKE, ESQ.
REV. S. SHARP.	WM. WEST, ESQ.
REV. T. BARNES.	

COUNCIL.

MR. H. BRIGGS.	MR. GEO. WILSON.
MR. W. T. HALL.	MR. THOMAS WILSON.
MR. H. HARTOP.	MR. W. R. H. JOHNSTONE.
MR. J. M. STANSFELD.	MR. HENRY CLARKSON.
MR. C. MORTON.	MR. W. H. DIKES.
REV. W. THORP.	MR. CHARLES CLAPHAM.

SECRETARY AND TREASURER.

MR. JOSEPH TRAVIS CLAY, Rastrick, Huddersfield.

HONORARY CURATORS.

MESSRS. T. W. EMBLETON AND HENRY HOLT.

AUDITORS.

MESSRS. BENJ. BIRAM AND G. W. CHAMBERS.

(Being the list laid upon the table in June last, according to Rule 13.)

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Mr. WILSON said he was sure the resolution he had to propose would meet with the cordial concurrence of the meeting. He begged to move—

That Professor Liebig of Giessen, Professor Daubeney of Oxford, and Dr. Lyon Playfair, be elected Honorary Members of the Society.

JAMES HAMERTON, Esq. seconded the resolution, which was carried unanimously.

The following Paper was then read:—

ON THE FAILURE OF THE RED AND WHITE CLOVER UPON CERTAIN SOILS.—BY THE REV. W. THORP, OF WOMERSLEY VICARAGE.

In the former paper read before our joint meeting with the Yorkshire Agricultural Society, I had the opportunity of applying to a local district near the river Humber those grand principles of the connection between agriculture and chemistry, discovered by the illustrious Professor Liebig. To him agriculture will ever owe a lasting debt of gratitude for the only rational system of its principles yet discovered, founded upon a chemical knowledge of the substances which plants extract from the soil, and likewise of those returned to the soil in the form of manure. To him we owe the knowledge of the sources whence vegetables obtain their nourishment,—why a method of cultivation may succeed on one farm and be inapplicable to another,—why a manure may produce great crops one year, and lose its fertilising influence in another;—in what manner a number of earthy and saline ingredients exert their influence in the vegetable organism;—that to have a vigorous vegetation, plants in the early period of their growth must be supplied with a due quantity of food;—that nitrogen, one of the most valuable elements,

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must be supplied by the cultivator;—and that "the chief art "of agriculture depends upon the collection and preserva- "tion of those manures which contain ammonia in the "greatest quantities." The loss in this kingdom of liquid manure, which abounds in this substance, has been estimated at an annual value of £7,000,000 sterling! But since the publication of "Chemistry applied to Agriculture and "Physiology," farmers are slowly opening their eyes to its value, and a better collection and preservation of it is now being made.

But if I mistake not, Professor Liebig points out in his work just published, "Organic Chemistry applied to Phy- "siology and Pathology," a discovery of no less value to agriculturists than any of those in "the Agricultural Che- "mistry." It is respecting *the necessity of warmth to animals during the time of their fattening; and also of a due supply being given them of nitrogenised food.* In that splendid treatise, which will be as enduring as the science of medicine, he indicates that in man and animals the body is a furnace to be supplied with fuel,—that the carbon of the food is the fuel which is burnt or oxydised by the oxygen of the atmosphere taken into the lungs; and the mutual action between the elements of the food and the oxygen conveyed by the globules of the blood to every part of the body, is the source of animal heat;—and that the amount of nourishment required by the animal body, must be in direct ratio to the quantity of oxygen taken into the system:—that the number of respirations, or the quantity of oxygen absorbed, is smaller in a state of rest than during exercise:—that the quantity of food must depend upon exercise, and that an excess of food is incompatible with deficient exercise. In order to keep up in the furnace a constant temperature, we must vary the supply of fuel according to the external temperature, *i. e.*, according to the supply of oxygen. *Our clothing is an*

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equivalent for a certain amount of food. The more warmly we are clothed, the less food is required, because the loss of heat by cooling, and consequently the amount of heat to be supplied by food, is diminished. The cooling of the body increases the amount of food necessary. "If we were to "go naked, like certain savage tribes, or if in hunting or "fishing we were exposed to the same degree of cold as the "Samoyedes, we should be able with ease to consume 10lb. "of flesh, and perhaps a dozen of tallow candles into the "bargain, daily, as warmly clad travellers have related with "astonishment of these people. We should then be able to "take the same quantity of brandy or train oil without bad "effects, because the carbon and hydrogen of these sub-"stances would only suffice to keep up the equilibrium "between the external temperature and that of our bodies." (*page* 22.)

A want of warmth, then, is tantamount to a waste of food, and if we apply this to the want of shelter to our sheep while feeding upon turnips in the winter season, when the temperature of the nights is frequently below the freezing point of water, and this over 3,000,000 acres of turnips in the kingdom, we shall find the loss of food very great indeed. Mr. Childers, of Cantley, and Mr. H. S. Thompson, of Kirby, have upon a small scale fed sheep in sheds during the winter, and the former says that the sheep in sheds consume nearly *one-fifth less food*, and make *one-third greater progress* than those fed with the very same food in the open field; or very nearly the same food will feed double the number of sheep. And a farmer in the *Doncaster Chronicle*, February 4, 1842, states that 1,760 bushels, or about 44 tons of turnips, kept him in a warm yard 200 sheep (Tegs) well for five months, while it would have required ten times that quantity out of doors. Mr. Morton informed Professor Playfair, that 200 sheep in the open field eat 24lbs. each of Swede turnips daily,

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while another 100 having a covered shed and a yard to run into at pleasure, only eat each 20 lbs. of Swedes, and gained 2 lbs. each more of flesh than the former.*

But, besides the waste of food induced by the want of shelter, must be added the want of economy in not using, together with turnips, food which contains more nitrogen. "The increase of the mass of the body (says Liebig), the "development of its organs, and the supply of waste, all "this is dependant on the blood, *i. e.*, on the ingredients of "the blood, and those substances only can properly be called "nutritious, or considered food, which are capable of conversion into blood. To determine, therefore, (he says) what "substances are capable of affording nourishment, it is only "necessary to ascertain the composition of the food, and to "compare it with the ingredients of the blood. But the "chief ingredients of the blood contain nearly 17 per cent. "of nitrogen, and no part of any organ of the body contains "less than 17 per cent. of nitrogen; and animals cannot be "fed on matters destitute of nitrogenised constituents. But "vegetable fibrine, vegetable albumen and caseine, are the "true nitrogenised constituents of the food of graminivorous "animals." And the learned Professor's book contains the discovery that these three vegetable substances contain the same organic elements united in the same proportion by weight, and, what is still more remarkable, are identical in composition with the chief constituents of the blood, viz., animal fibrine and albumen. These vegetable principles contain the chief constituents of blood, fibrine and albumen ready formed. Vegetable fibrine and animal fibrine, vegetable albumen and animal albumen, hardly differ, even in form. "If these principles be wanting in the food, the

* Experiments regarding the relative feeding properties of different kinds of food, are of no value unless the temperature of the places in which the animals are fed, be the same.

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" nutrition of the animal is arrested; and when they are " present, the graminivorous animal obtains in its food the " very same principles, on the presence of which the nutri- " tion of carnivora entirely depends."

To apply these discoveries to our present mode of feeding sheep on turnips.—According to Dr. Daubeney's table in his valuable paper "On the application of Science to Agriculture," turnips contain in about 50 tons, or 100,000 lbs. weight,

99.274 lbs. water and carbon.
.556 fixed ingredients.
.170 azote.

100.000 lbs.

Now 25 tons, being an average weight for one acre of land, will only contain 85 lbs. of nitrogen; hence we may see the necessity of adding grain, as practised by Mr. Childers and Mr. Thompson. The former states that sheep fed with the addition of half-a-pint of barley per sheep per day, $\frac{1}{2}$ lb. of linseed cake, a little hay, and with a constant supply of salt, become ready for the butcher in ten weeks, with a gain of flesh and tallow of from 33 lbs. to 40 lbs. per head: (one sheep gained 55 lbs. in twelve weeks:) and that with artificial food, 30 tons of turnips will feed 60 sheep:—(*Journal of the Royal Agricultural Society, vol.* 1, *part IV, p.* 409)—while on the usual plan of feeding on turnips alone out of doors, the average of the country is, that 20 tons of turnips will feed in sixteen weeks 10 sheep, with a gain of only 20 lbs. of flesh and tallow. The barley and cake cost 6d. to 10d. per week for each sheep, *and the turnips with this addition thus go eight times as far*, or *produce eight times the amount of flesh and tallow.**

The practice of Belgium is also in strict conformity with the principles here laid down by Professor Liebig; for not only

* The turnips alone go *four* times as far, for 30 tons feed sixty sheep, while on the usual plan of feeding they would only feed fifteen sheep: but the same weight of turnips with artificial food produce also very near *double* the amount of flesh and tallow, and, therefore, go eight times as far.

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are all their animals kept up and fed in houses, but the mixture called "*vrassin*" consists of the flour of nitrogenous grain mixed together with roots; and there is little doubt that the high price of meat in England, which has a less population per square mile than the Netherlands, is in part owing to one of the three sources of waste and loss indicated by Professor Liebig. At all events, *the value of nitrogenous manures, the necessity of warmth to animals during the time of feeding, and the use of those vegetables which contain nitrogen, must ever remain as fixed principles in Agriculture.* Without principles, says Cullen, deduced from analytical reasoning, experience is a useless and blind guide. Moveable sheds are now used for keeping sheep warm during feeding, so that there shall be no loss to the land from the treading of these animals. Or, what is still preferable, one-third to one-half of the turnips may be drawn off, and by giving oil-cake or barley to the sheep which consume the other half on the land, as good barley and seeds may be obtained as if all the turnips had been eaten on the land.

A severe loss frequently occurring to agriculturists is the destruction of the red and white clover crop, the cultivation of which is of so much importance, that every exertion should be made to secure a full crop; for upon its success depends the number of sheep to be sustained during the summer, the quantity of fodder for horses in the winter, and the ensuing corn crop is materially influenced by the weight of the produce consumed on the land. There is, however, in this climate no plant more difficult of culture in the early periods of its growth, or which so frequently fails in its progress towards maturity, or of which by repetition the land is said to be so soon tired. Upon the Magnesian Limestone nearly one-half of the red clover sown, fails, (200 acres out of 450). Upon the Chalk wolds of Yorkshire, owing to frequent failures, many farmers have given over sowing red clover, while the white clover is very often only half a crop;

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and upon the Oölites and other light soils of the New Red Sandstone and of the Coal district, red clover, owing to frequent losses of the crop, is only sown once every twelfth year. An inquiry, therefore, into the causes of these general and extensive failures of this plant, and consequent loss to the farmer, cannot but be of advantage.

In the Paper before alluded to, the causes of failure *at the time of sowing, and during the summer months*, have already been pointed out, and it is, therefore, to the failure of the clover crop *after harvest* that the following remarks will be more particularly directed. In this case the crop after harvest is always good, but dies away during the months of November, December, January, February, and March, the lands on which this occurs being denominated "clover sick," from a supposition of the too frequent repetition of that crop.

The Committee of the Yorkshire Agricultural Society, in the Report of last year, directly ascribe the failure to *the exhaustion of some food required by the clover.* They say—"Mr. Thorp has collected a great mass of evidence to prove "that on certain soils clover may be grown at short intervals. "The Committee, on the other hand, have shown that certain "other soils will not grow it with advantage oftener than "once in twelve years. These apparently contradictory "facts may be reconciled on the supposition of *the food of* "*clover being exhausted.*" Mr. Legard, in the same Report, says, "On the much controverted question of clover sick-"ness, my opinion is, that the soil is rendered unfit to pro-"duce successive crops of this plant, either by excretions "given out by the roots, or by the exhaustion of certain "constituents of the soil by the plant itself." (*Report of the Yorkshire Agricultural Society*, 1841, *p.* 136.)

In order, if possible, to ascertain whether this opinion of the food being exhausted was correct or not, two samples of soil were sent for analysis to Mr. Spence, of York, a very

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acute chemist, recommended by Professor Phillips. The samples were taken from the same field, about ten yards apart, being upon the lower bed of the Magnesian Limestone. This field is sixteen acres in extent, one half of which had been seeds (*i. e.*, white clover and rye grass), and the other half, beans four years ago; the whole of it, last year, was barley and red clover; and both portions of the field had previously been under the same management with respect to crops and manures. After harvest, the whole of the clover was equally good, but during the months from Nov. to the 5th April, the clover had, I may say, totally disappeared from the portion which had four years before been "seeds," except upon the headlands where the horses had turned round in the ploughing. Upon the portion which had been beans four years ago, the red clover continued excellent until it was mown, but the other half not being worth keeping, was ploughed up and sown with beans.

Mechanical Analysis.	SOIL OF THE SICK CLOVER.		SOIL OF THE GOOD RED CLOVER.	
Deposit in 3½ minutes	90		90½	
Remainder	10		9½	
	100		100	
	Chemical Analysis.		*Chemical Analysis.*	
Water of Absorption	4.5		4.5	
Water not expelled at 300°, and matter destructible by heat	3.5		3.5	
Sulphate Lime, Chloride Sodium	0.15		0.10	— .05
Vegetable matter (soluble)	0.10		0.10	
Siliceous sand, insoluble in Hydrochloric and Sulph. Acids	80.5		79.50	— .55
Alumina	4.6		4.8	— .2
Oxide Iron	4.65		5.8	— .35
Carbonate Lime	1.25		1.15	— .1
Carbonate Magnesia	0.25		0.45	+ .2
Phosp. Lime (Phosp. Acid 0.67)	0.15	(Phs. Acd. 0.9)	0.2	+ .05
Potash (silicate) (Potash 0.17)	0.35	(Potash 0.2)	0.4	+ .05
	100		100	

An acre of red clover contains of potash 45 lbs., soda 12 lbs., lime 68 lbs., magnesia 7.5 lbs., alumina 0.3 lbs., silica 8 lbs., sulph. acid 10 lbs., phosphoric acid 15 lbs., chlorine 8 lbs. (*Lectures on Agricultural Chemistry, by J. F. W. Johnston, p. 326.*)

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The analyses of both soils are here given, and the comparison shows the soil of the bad clover to be actually richer in gypsum and common salt than the soil of the good clover; it, however, contains a little less magnesia, phosphate of lime, and of silicate of potash. But by comparing the extract from the table published by Professor Johnston, which contains the number of pounds weight of inorganic substances required per acre, with any of the ingredients in which the bad soil is deficient, it will be found that there existed in the bad soil quite an ample quantity of each of them. Take the quantity of phosphate of lime, the only one about which there can be a doubt, the quantity in the analysis being 0.15 per cent., and therefore of phosphoric acid 0.67 per cent.; but a crop of red clover requires of phosphoric acid only 15 lbs. weight per acre, and an acre of this soil, six inches deep, weighed on the 5th of April 2,766,060 lbs., and therefore contained 180 lbs. weight of phosphoric acid. So that if the analysis had contained only .001 per cent., it would have contained 27 lb.: nay, if it had contained .0005, it would have contained nearly sufficient, not only of phospheric acid for the red clover, but also sufficient chlorine, sulphuric acid, magnesia, and soda, for either a crop of barley, rye grass, or wheat. This shows that even the very minute analyses of soils given by Professor Liebig are not sufficiently exact, although they exhibit the thousandth part per cent. of the substance analysed; yet before it can be asserted that any soil is deficient in alumina, soda, sulphate, acid, or magnesia, chemists must, owing to the small quantity of matter required in so large a mass, give us less than one-half of the decimal parts afforded in those even by Professor Liebig. In fact, before it could have been predicated whether the clover on this soil had failed for the want of alumina, it must have been ascertained whether the soil contained even .000011 per cent. of that earth.

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But in addition to the positive evidence afforded by the comparison of the analyses of the two soils, that there is no exhaustion of the food of the clover, we have the high authority of Professor Liebig, who says—"In some neighbourhoods clover will not thrive till the sixth year, in others not till the twelfth; flax in the second or third year. All this depends on the chemical nature of the soil, for it has been found by experience that in those districts where the intervals at which the same plants can be cultivated with advantage are very long, *the time cannot be shortened even by the use of the most powerful manures.* The destruction of the peculiar excrements of one crop must have taken place before a new crop can be produced."

Indeed, Mr. Legard himself almost proves that its failure cannot on the Chalk Wolds be ascribed to the want of any ingredient of the clover, when he says—"That for a period of 18 years he has used bones to the turnip crops at the rate of two quarters per acre; to the clovers, rich farm yard dung, 10 tons per acre; and to the wheat crops, rape-dust at the rate of 12 bushels per acre; and that the clover crops have been consumed on the ground by sheep."—Surely if land be manured in this way, no exhaustion of the soil can take place. And upon the Magnesian Limestone it is scarcely possible that exhaustion of any specific ingredient can be the cause of failure, because it is the custom to sow beans upon these "clover-sick" lands wherever the soil is not very shallow; and if a good crop of beans can be grown on the same lands, it follows that certain fixed ingredients must have been present in the soil, for beans contain as much potash, soda, magnesia, alumina, and silica, as red clover, but a little less gypsum, phosphoric acid, and chlorine; but not an absence of the three last, otherwise they would not grow at all. In fine, this single consideration alone, that the clover flourishes luxuriantly during the warm and growing

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months of the summer, when food of all kinds is required and assimilated by the plant, but perishes in the colder months, when vegetation is nearly dormant and scarcely any nourishment required, must preclude the opinion that the want of food of any description whatever is concerned in its destruction.

Will an excretion, or rather the emission of excrementitious matter from the roots of clover, account for its disappearance? for in this opinion Professor Liebig coincides with that of the Committee of the Yorkshire Agricultural Society. But against such an agent being concerned, it may be urged in the first place, that there are certain light lands which have been reclaimed some 30 years ago, and therefore never have produced clover at any former period, but upon which the crop always disappears in the winter. A farm near Barnsdale bar, on the Magnesian Limestone; several farms on the south side of Darrington, on the same geological formation; and certain portions of the Yorkshire Wolds are in this predicament. No excrementitious matter, therefore, can destroy the clovers on these farms, because they have never grown the plant. Macaire Princep found that the Leguminosæ (to which family the clovers belong) emitted gum and carbonate of lime. But the gums are very soluble in water, and therefore would be easily washed out of the soil; and it seems very extraordinary that in the heavier soils, consisting of loam and clay of the New Red Sandstone, this *gum trifolii* should only remain three years, while in the lighter soils of the Magnesian Limestone eight years, but in the still more open and porous soils of the Chalk Wolds it endures twelve years. In fact this wonderful substance, contrary to the known law of eremacausis, decomposes more slowly in proportion to the porosity of the soil, and in those containing the most calcareous matter. Again, if this excretion can remain in the soil nearly twelve years, it must be

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decomposed very slowly, and therefore afforded to the plants in a very weak solution; but Saussure found *that plants do not suffer much by weak solutions of poisonous matters.* Again, it seems very singular that the poison is only absorbed in the winter months, when vegetation is languid, and that the clover from this cause should not perish during the warm months, —the period of its greatest growth. But the red and white clovers are perennials: Smith, in his *English Botany*, describes them as such. The red clover grows as a perennial in the vale of Aylesbury and in the rich pastures of Lincolnshire; and Mr. Baines, the editor of the *Flora of Yorkshire*, says that it grows as a perennial near York. Now, if this plant excretes in one year as much as will poison the soil upon which it grows for ten or twelve years, how is the same plant enabled to live continually in the midst of its own accumulated excretions? In fine, the conclusions of Macaire's experiments have been disproved by Meyen and Unger. They obtained excretions from those plants only whose roots had been mutilated by their removal from the soil into water, which is not their natural medium of growth; but in employing water plants, and placing them in various solutions, they could not detect by the most delicate re-agents, the rejection of any of the absorbed agents.*

But an anatomical and pathological examination of the dying red clover plant, will prove that no poison received by the roots is concerned in its death; for plants which are poisoned assume a very different appearance.

During the last winter I took from different fields, and particularly from the clover-sick portion of the before-named field, a great number of dying plants, at different periods of the winter, and examined them with the microscope; slices of whole stems and leaves were placed under a magnifying power of 100 to 150 diameters. The part first injured is

* See "Root," Penny Cyclopædia.

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the neck of the plant (collet,) about a quarter of an inch below the point where the leaves join the stem. If slices of the neck be placed under the microscope in the early stage of the injury, the sap vessels are found simply ruptured; while if the plant has been some time affected, as shown by its foliage, a dark spot will be seen in the centre of the stem, and the more external parts of a brown colour; and as the disease spreads upwards, the leaves and stem become black in their entire thickness, decomposition takes place, and the plant rots away a little below the base of the leaves. This destruction of the cellular tissue is owing to *the severity of the frost;* and if the common cauliflower, or the celery plant, at the same period of the year, be examined, the same effects will be visible. In the cauliflower, about three inches below the leaves, the centre of the stalk is found in its early stage, simply softened; afterwards it assumes a brown colour, and emits, if broken, a putrid smell, decomposition having taken place. In the celery plant the neck becomes filled with a brown sap, and the blanched leaves soon take on the appearance of frost-bitten celery. The first external symptom of the disease in all the plants is a dead appearance of the edges of the leaves; which takes place first in those most developed, while the leaves recently expanding seem healthy; but subsequently the whole plant above the neck becomes of a dark colour, and, if pulled, breaks off, leaving the lower portion of the roots healthy in appearance. There is no doubt that the disease is immediately caused by the sap of the plant becoming frozen, and the air which is contained in it expelled among the sap vessels. The heat of the sun then expanding the confined air, before the re-absorption of it by the frozen sap can take place, bursts the vessels of the plant. This is proved by the fact that any frosted plant may be preserved if it be gradually thawed, by either pouring cold water upon it, or by protecting it from the sun's rays. Several hundred plants of

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red clover, from different localities, were examined during the winter, and the same effects were always visible.

A number of plants were taken up and placed in a stove in their native soil, having a temperature of 60° to 65°. Of those taken up in November, about one-half of them continued to live, while of those taken up in January all died; some of the latter had their soil changed, but they also died away in about ten days. Of those plants which were taken up early in the season, some of them survived, because their sap vessels were not irremediably damaged; while in those taken up later, the vessels were destroyed to an extent incompatible with the life of the plant.

It being proved, then, that the clover crops are destroyed in this country by the frost, the next inquiry is—Why are they injured on particular soils, or sometimes on a soil where this crop has been successively grown,—as every third or every fourth year? Upon certain soils of the New Red Sandstone at Fishlake Fenwick, red clover has been grown every third year for a series of years (this is shown in the *Yorkshire Agric. Report, page* 125); while upon portions of the Chalk Wolds of Yorkshire, neither red clover nor white clover can now be scarcely cultivated at all; and it may be safely asserted that it is only upon the more pulverulent soils of the Magnesian Limestone, of the Chalk and of the Sandstones of the Coal Measures, and some of the lighter soils of the New Red Sandstone and Oölite, that this crop is injured by the frost. If it is destroyed on a stiff soil, it is from an excess of water and because it is too wet; the natural habitat of red clover being a dry compact loam, firm and close on the surface.

The true answer to this inquiry is, that the cause of injury by the frost is owing *to the want of a certain degree of cohesiveness of the particles of the soil among themselves*, and hence the soil's power of retaining heat is diminished;

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and those plants, particularly clovers, which are impatient of sudden change of temperature, are readily destroyed by the frost.* And soils by the growth of white clover, red clover, and tares, become more pulverulent, puffy, and less cohesive in proportion to the frequency of the growth of these crops, and this explains why these lands *tire* of clover. The several particles of earth, by the long, deep, and numerous radicles of these plants, become mechanically forced from their position, and their points of contact thus rendered fewer in number; and such soils comparatively between themselves become specifically lighter in proportion to the weight of a determinate volume. That the soils upon which the clover is destroyed do lose the cohesiveness of their particles, and, when compared with those of the same chemical constitution which preserve the plant, are specifically lighter in proportion to the weight of a determinate volume, is proved by the following trials, in which a solid foot of each was dug from the ground and weighed upon the spot.

In the two portions of the field whose soil was analysed, several trials of the weight of the two soils gave a difference of 6 lbs. to 7¼ lbs. per solid foot (of 17 × 17 × 6 inches, or 6 inches in depth) or from 117 to 140 tons weight per acre over and above the failing or sick portion of the field: and this difference of the weight does not arise from a difference in

* "The power of retaining heat is nearly in proportion to the weight of a determinate volume of soil, *i. e.*, to absolute weight; the greater mass an earth possesses in the same volume, the greater will be in general its power of retaining heat—we may, therefore, from the absolute weight of an earth, conclude with a tolerable degree of probability, as to its greater or less power of retaining heat." *(Schubler on the Physical Properties of Soil, p. 177, vol. I. part 2, Journal of Royal Agricultural Society of England.)* "When different earths are mixed together, a cubic inch of the mixture obtained gives a greater weight than the arithmetical mean (or common average) of the earths, entering into the mixture, whether mixed in equal portions, according to weight or volume, or in other quantities." *(Ibid, p. 181.)*

e. g. 2 parts of sand and 1 part of clay, by volume, have an arithmetical mean weight of 2.566, while the actual weight is 2.825, or an increase of 259.

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the specific gravity of the two soils (indeed, the lighter contains more silica), but from the particles of earth not being in equally close contact.

In another field belonging to Mr. W. Stephenson, of Womersley, upon the New Red Sandstone, which is rather peaty and possesses a subsoil of clay, one portion of it was Swede turnips, which were pulled off; another potatoes; a third white turnips, which were eaten off the ground with sheep; a fourth portion open fallow, manured with rape dust. All these different pieces were sown with barley and red clover; but the red clover disappeared in the winter from all except one, viz., the white turnips eaten off with sheep, and the soil of which weighed—

11¼ lbs. per foot of six inches deep, or about 216 tons per acre more than the swedes.

5⅛ lbs. per foot of six inches deep, or about 100 tons per acre more than the potatoes.

10¾ lbs. per foot of six inches deep, or about 200 tons per acre more than the open fallow.

The treading of the sheep in eating off upon this soil added a weight of 11¼ lbs. per solid foot, and the additional density and compactness in the soil of this particular piece, evidently enabled the red clover upon it to endure the severity of the winter.

In a field in the occupation of Mr. Ruddock, of Wentbridge, upon the Magnesian Limestone, which was an open summer's fallow, but in the spring was sown with barley and red clover, the latter died away in the winter from all parts of the field, except upon those headlands where the horses had turned round in ploughing. The good clover soil gave an excess of 5¾ lbs. per foot in weight (or 100 tons per acre) over the soil which had no clover upon it, but which was covered with weeds.

In a field belonging to Mr. Rowley, of Kirk Smeaton,

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situated upon the Red Marl and Gypsum, between the two beds of Magnesian Limestone, one portion was oats and very inferior white clover; the other portion was barley and very good white clover. The soil of the good clover, which was firm and dry, gave 6¼ lbs. per foot (of 17 × 17 × 6) or about 120 tons in weight per acre above the inferior portion. One half of the inferior portion was manured with gypsum thrown from a deep drain, but the frost equally destroyed the clover upon it.

In several trials of the soils of fields, where circular patches only of the clover had disappeared during the winter months, the result was invariably the same, viz., a lighter weight of the soil, and that averaging from 6 lbs. to 9 lbs. per solid foot of six inches deep and 17 inches square.

In another field belonging to Mr. Stones, of Kirk Smeaton, which was examined without knowing under what circumstances the clover had failed, two trials gave only a difference per solid foot of ½ lb., between the portion which had good red clover upon it and that which had no clover. In this case, however, the farmer assured me that there was no clover after harvest to be seen, and that it had been destroyed by the barley crop being excessively luxuriant, and which was "lodged."

The theory here offered of the failure or destruction of clover after harvest, viz., that it is always killed by the frost, and this in proportion to the want of a certain degree of cohesiveness of the particles of the soil, will alone explain all the contradictory opinions that have been offered respecting the causes of its failure.

1. It explains why some lands, as those situated upon the Chalk, Oölite and Magnesian Limestone, mentioned in the Report of the Yorkshire Agricultural Society, after being "*tired*" are by rest able to re-produce this crop;—because the more frequently the clovers or tares, or any large tough rooted

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plant are sown, the less compact and lighter in weight does that soil become, and at length there is produced an incapacity of the clovers growing upon them to resist the frost; yet in time, by the decomposition of these roots, and the cultivation of bulbous rooted crops, and the treading of the soil by sheep in eating them off as is usually practised, reconsolidation of the soil takes place, and the same land is thus enabled again to sustain clover against the severity of the frost.

2. It explains why, in some fields from which the whole crop has nearly disappeared, the headlands where the horses turn round in ploughing, usually preserve the crop untouched by the frost. This is particularly observed on the Wolds.

3. It explains why, on the strong tenacious clay lands around Hemsworth, red clover, after teasels, invariably fails, while upon the Magnesian Limestone, particularly around Kirk Smeaton, red clover, after teasels, succeeds better than after any other crop;—because in the one case the continual treading of the teasel spitalers and reapers makes the strong land too tenacious; while the same on the light and porous limestone, affords the consistency required to preserve the crop over the winter.

4. It explains why in Scotland the best remedy for clover sickness yet discovered is to allow sheep-seeds (consisting of white clover, cow grass, rye grass, &c.) to remain down three to six years if possible, without being ploughed up; because by the continual treading of sheep, these lands are rendered firm and compact, and the red clover grows in spite of the excretions or exhaustions of three to six years' duration.

5. It explains why certain portions of the Magnesian Limestone will produce red clover every fourth year, other portions only every eighth, others every twelfth, while other portions, as at Barnsdale, on the south side of Darrington, &c., will not, with the heaviest manuring, produce this crop at all, so as to stand the winter;—because the compactness of the lime-

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stone soils is very variable; some require pressing for wheat, others do not; some contain 5 per cent. of alumina, others not 1 per cent.; some 12 per cent. of lime, others not 2 per cent.; hence, upon the more compact, the clover will stand the winter, while upon other portions it will not do so.

6. It explains why, in the south of England, a working flock of sheep is of so much value;—because by their treading they give great solidity to the soil, and also a capacity to the clovers upon it to resist sudden changes of temperature.

7. It explains why claying or marling clover-sick lands, as mentioned by Mr. Morton *(page 77, Agricultural Report,)* should in Norfolk be a sufficient remedy;—because clay and marl give tenacity to the soil, and the power before mentioned.

8. It explains why lime is called the mother of seeds to certain soils;—because this earth is one-half of the value of clay in giving tenacity to soil. *(See page 185, Journal of Royal Agricultural Society of England, for 1839, part II.)*

9. It explains, for the same reason, why chalking upon the Yorkshire Wolds is of so much value to the clover crops; indeed, by walking over these lands it may at once be told whether the land has received this operation by the firm sensation conveyed through the feet.

10. Lastly, it explains the failure of the numerous trials of the growth of the Trifolium incarnatum (the scarlet clover,) which would be an invaluable plant, but it invariably dies in winter if sown upon land recently ploughed; while, if the stubble land before sowing be simply scratched by light harrows, and after sowing compressed with a heavy roller, it will stand the winter.

Sprengel remarks that the clovers delight in a close topped soil, or one which admits no great quantity of oxygen to the roots. The best clover grown in Great Britain is upon the warp soil in Marsh-land near the river Humber, for not

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only is such a soil dry and compact, but it abounds in microscopic animalculæ. Ehrenberg has discovered that the mud of the various harbours in Europe is composed to the extent of from one-third to one-half of its volume of distinguishable organic bodies, chiefly polythalamia, from the nitrogen of which no doubt these soils derive their fertility.

The cause of the failure of red and white clover after harvest being ascertained, the remedy is easily prescribed, for farmers have many ways of imparting compactness to the soil, namely, by rolling and pressing the surface, by claying, chalking, and lining with caustic lime. I should say,—Lime the clover ley when broken up for wheat, press the wheat, and also press the soil for barley; and after harvest before November, roll the barley with a heavy roller; and the probability is that we shall hear no more of clover-sick lands: at all events, the remote and proximate causes of the disease being discovered, I leave the remedy to the farmer.

Agriculture, as a science, has been for a long period in the same state in which the healing art was in the days of the celebrated barber-surgeon Parè—a system of empiricism—a few recipes applied indiscriminately to all cases under all circumstances, without any pathological knowledge of the morbid tissues or fluids of the organism to which the remedy was to be applied. But a brighter day is beaming; the sun is already above the horizon. If there arose for the advancement of medicine a Harvey who discovered the circulation of the blood, there has now sprung up for the advancement of agriculture a Liebig, who has discovered how simply the Great Creator forms that blood from the sap of vegetables—in what manner it conveys heat to every part of the body—from whence it derives its nutrient particles, and which must be given to animals in those vegetables which contain them, according as the animal is intended to be kept lean or fat. If for medicine Bechat and Baillie observed

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the diseased actions of the body, and described the various forms and stages which the tissues assume under that action,—if Laennec, by auscultation, added another sense towards the discovery of diseases in the animal frame, Liebig, Boussingault, and Sprengel, for agriculture, by exhibiting the most perfect analyses of soils, and showing the requirements of the land on the one hand,—and by affording tables made with the most exquisite skill, containing the composition of cultivated plants, on the other,—have taught us the true principles upon which we are to investigate the causes of failure in our crops, and the want of fertility in the soil. If for medicine Sir Charles Bell discovered the functions of the nerves of volition, and of the nerves of sensation,—the analogy of the trifacial nerve, both in structure and functions, to the spinal nerves,—and the tractus respiratorius of the spinal column,—Liebig, for agriculture, has discovered the origin and source of the vital chemical and mechanical forces in the whole animal organism,—the adaptation of the bile to the purposes of respiration,—the subserviency of the excrementitious waste of bodies, in the great cycle of the transformation of Nature, to the production of crops and the support of the human species.

Dr. Buckland said, that circumstances had hitherto prevented him from expressing his sincere thanks to the Society, for having on a former occasion elected him an honorary member. Having performed that duty, he now wished to thank Mr. Thorp for the valuable Paper which he had just read. It was indeed a matter of great importance that agriculture had attained the position which it now enjoyed; that chemical investigation was being applied so successfully to those pursuits on which the growth of the food of mankind depended. Mr. Thorp had given an able analysis of Professor Liebig's work, which had opened a new field for

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scientific research; but the facts now brought forward proved that something more was requisite than a knowledge of the chemical constituents of the soil; for it appeared that while crops of clover had failed on soil which apparently contained every element of nutrition, they had flourished upon land that was inferior in this respect; and it followed that the mechanical condition of the soil, i.e. its compact or loose state, was a matter to be attended to in considering the causes of fertility and barrenness. He had lately seen an instance corroborative of Mr. Thorp's views, where a sandy soil had become compact from the constant treading of horses, and now for the first time was covered with a luxuriant crop of white clover.

Dr. DAUBENY then rose and said,—Ten years ago, when he came from Geneva, he was fully impressed with the truth of the theory that every plant excretes a certain substance which is poisonous to itself, though it may prove nutritious to others. He had made experiments, and although the result arrived at showed that a deterioration takes place in ground not manured, yet, it did not appear that in the generality of crops the excretions which plants throw out are poisonous. He would not dwell on the explanation offered by Mr. Thorp, but he might mention one circumstance with regard to clover, which was, that some planted near a margin of box had grown luxuriantly. It would seem that it was not owing to the soil, but that it was owing to a nutritious matter which had been supplied by the box. He would just allude to one effect which might confirm one part of Mr. Thorp's statements, respecting the necessity of warmth for a reduction in the food of animals. Two swarms of bees had been put together, and the mutual heat communicated to each other was such, that they actually consumed less food than one swarm would have eaten if they had been separate. He would conclude with these observations, and with expressing

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the honour he felt at being connected at this meeting with the distinguished persons around him.

Dr. Lyon Playfair briefly returned thanks to the Society for having elected him one of its members.

Professor Liebig made a few observations in the German language, and at the request of the Chairman, Dr. Lyon Playfair stated that Professor Liebig had said, that owing to his ignorance of the English language, he was unable to express, except in his native tongue, his thanks for the honour they had conferred upon him in electing him a member of the Society.

The Chairman then called upon Mr. Hamerton to read the following paper.

ON ARBORICULTURE.—BY JAMES HAMERTON, ESQ., HELLIFIELD PEEL, SKIPTON.

I purpose in the following remarks to demonstrate the great loss which gentlemen suffer in the management of their plantations, by keeping too many trees on the ground, a treatment by which they can never arrive at maturity. I next wish to make intelligible the great and valuable increase of wood annually, where trees have room allowed to grow; also the injurious effects of injudicious pruning off large branches. I do not mean to object to what may be done with the knife in a state of infancy, when trees are under six feet high: my observations are aimed at pruning off large branches with the axe and saw. I purpose, by drawings taken from nature, to put it in the power of any gentleman to know and calculate what per cent. he is obtaining by the annual increase of his timber. These are the great national advantages I wish to exhibit to view, than which I know not any of greater importance.

I will not allow myself to give the names of the owners of woods and plantations from which my specimens have been

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taken, for fear of misconstruction of my motives, or I could mention some who are losing *many, many* thousands, by their neglecting to cut away trees in time,—there are many instances in this county, particularly in the East-riding.

It is not well, when endeavouring to divest people of old prejudices and customs, to encumber them with elaborate details; men are apt and prone, when such a system is adopted, to view the matter as too abstruse for their consideration, and leave it to cold neglect. My details will be found as few as possible. It is the object of the present paper to place before the gentlemen of England the advantages of cultivating timber,—by a great number little regarded or even thought of.

I have endeavoured to bring the public to try, what I may term an issue—viz. timely thinning of trees—without allowing the mind to be distracted with other considerations. I have brought what evidence I was able, to entitle me to a verdict; and when the mind is directed to one subject, its powers are not concentrated in vain, since the faintest rays, if collected into a focus, can produce some illumination. It would almost seem to be the intention of man to prevent a tree becoming timber, rather than to encourage it.

Visible representations strike the mind more forcibly than mere descriptions. It is therefore presumed that subsequent illustrations will be an acquisition, by bringing vividly to the imagination objects of which only an imperfect idea could otherwise be formed, and that they will consequently render these observations more intelligible to the general reader.

I tread, I believe, an untrodden path; but I could wish that all might travel the same, and convert it into a highway. I am well assured that there is not any subject more deserving of the attention of mankind than arboriculture. Perhaps not in any way can money and time be expended to more advan-

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tage than in the culture of forest trees. I have not written this merely to intrude my opinions on the world, but to excite attention—to raze out rotten opinion—to provoke inquiry—to battle with prejudice—and to dispel the doubts and fears which many gentlemen of large landed estates entertain. I will not here discuss the beauty and value of trees, which generally go together; but will confine myself more to their actual improved value in solid cubic feet; and there is the additional value derived in many instances from their shelter in mountainous districts giving birth to a more valuable herbage; and lastly, in many instances, affording shelter to the domain.

Agriculture in all its branches advances with rapid strides, though yet capable of very great improvement. But while agriculture advances, arboriculture remains stationary,—I may indeed say retrogrades, since a very great majority of the plantations of the present day are never likely to produce the timber of former ages.

The objects of horticulture, its kindred science, are studied with every possible care and attention; even mushrooms are tended with a nurse's care; while the oak, not only the pride of England, but of the world, and from which we obtain the chief material of our navy, the bulwark of our country, is left to thrive or rot, almost unheeded and forgotten. Most people think that when a tree is planted in the ground the planter's care is ended: this is a very common and pernicious error. It ought never to be forgotten, that a man may understand the planting of a tree, while he is totally ignorant of its culture: both are essential to the planter's ultimate success. The former knowledge is common; every gardener knows something of it; it is also diffused in books, in which he who reads may be able to practise with tolerable success; but this is not, I apprehend, the case with the latter.

There is great necessity for investigating this subject, when

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it may probably appear that the scarcity of such knowledge is in a considerable degree the true cause of the scarcity of timber. " Felix qui potuit rerum cognoscere causas."

It is many years since the subject first engaged my attention, when I resorted to books, from which I derived nothing but perplexity and disappointment, and it appeared evident I could obtain little assistance from that quarter. From books I turned to woodmen, and, with some exceptions, with similar success. I then had recourse to nature and reason, from which I have collected all I know with any tolerable certainty on the subject. Evelyn, in his " Silva," says that owners " appear to have paid no attention to this subject, though it is " their interest so much to do." It has been said that timber is only an excrescence to pay people's debts with, and no doubt many woods have been cut down for that purpose. Few writers appear to be fully aware of the importance of the subject, and the generality of managers appear, by their works, to be no better informed as to the rate at which timber increases in value, though Evelyn has given them broad hints of it. He says that country people know that trees consist of roots, stems, boughs, and leaves, &c. &c., but cannot give any account of the species, virtues, or further culture, than making a pit or hole, and treading in the earth; and they seldom plant trees till they grow old, and find by experience the prudence and necessity of it; and there is no part of husbandry which men more commonly fail in, neglect, and have cause to repent of, than that they did not begin to plant betimes, without which they cannot expect much fruit from their labours.

In all the books I have read on the subject of arboriculture by Evelyn, Duhamel, Pontey, Boutcher, Monteath, &c., instructions are given to enable planters to know what trees to plant on particular soils and situations; various experiments as to the strength, growth, and qualities of

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wood; what distance to plant trees asunder, &c.; but no book with which I am acquainted points out the injuries consequent on the present system of keeping all the trees on the ground as they were planted,—too frequently pursued,—with the exception of a small paper in a horticultural magazine, written by Mr. Joshua Major, of Knostrop, near Leeds. Trees are usually planted of the height of two feet, and at three or four feet asunder, and if this distance is considered sufficient in the beginning, why is it not considered right to preserve a similar proportion, *at least in some degree*, as they grow up? and I find I am supported in that opinion by Mr. Major, that they are allowed to remain as they were planted; I will give Mr. Major's own words. He says—"I find "wherever my profession calls me, I observe very great and "glaring defects in plantations, arising, in nine cases out of "ten, from the want of early and judicious thinnings. Now "could we persuade gentlemen, and persons who have the "management of plantations, to commence thinning a few "years after planting, and to continue to do so once in two "or three years, as it is necessary, the defects I complain of "would be prevented, and the object I have in view effectually attained. We generally find plantations wholly neglected for the space of fifteen or twenty years, and sometimes even longer, and that, though the trees were planted "at no greater distance than three or four feet from each "other: such management must cause the branches to decay "and fall off, and consequently leave the trees little better "than naked poles, miserably ill calculated to form a screen "or to ornament the surrounding landscape:" I may add, with only a brush at the top, and I appeal to any one conversant with mechanics, what tremendous power the wind would have upon trees 10 or 12 yards high, and having little root hold. But it is perhaps useful that such as Mr. Major has described should here or there be preserved for the benefit of

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physical science, as by the anatomy of distortion and proportion, we learn to measure the harmony of grace and beauty. Mr. Major represents himself as forcibly struck with the necessity of something being done on a subject so important, he having noticed plantations that had stood at least thirty years, the trees not more than from three to four feet distant, and totally neglected. He mentions that, in one nobleman's grounds, several masses of silver firs, which would have been the finest of the kind he had ever seen had they been properly managed, being from seventy to eighty feet high, were destitute of branches to within ten and twelve feet of the top, instead of being furnished nearly to the ground, as they might have been, had they been planted at a proper distance at first. He finally adds, "these are not mere fanciful observations, "they are the result of attentive views."

Independent of this injurious system, I cannot consider any thing so offensive to the eye of a man of taste, as one tree dying under the shade of another, nor any thing which common sense would more repudiate. The sickly tree can never arrive at maturity itself, but, while it remains standing, will rob the good one, its immediate neighbour, which might arrive at maturity, of the nourishment which should go towards its support; but such things I have too often been obliged to witness.

Talk to some people of mechanics and manufactures, the value of canal and railway shares, the great rivals of the present day, and they will give you their attention, while to this subject they turn a deaf ear, and allow their woods and plantations, which hold out such great profits, to go comparatively to ruin. Should any one have a young wood, and commence cutting away a certain portion of it every year, he is reported to be wasting his property, whereas, by taking a certain portion out annually, he puts money in his pocket, and is at the same time laying by a sinking fund in the

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improved value of that which is left standing, which every succeeding year increases, if not in number, *in value :* and if any one will observe a young wood in which the trees are very close on the ground, he will always find the finest at the outside, where more air and light is obtained.

If trees are planted, and too many are kept on the ground and allowed to stand without any being taken away, a mortification of the root takes place, the whole plantation suffers in health and becomes stunted in growth, and moreover there is no mode of thinning it afterwards to keep a proper crop of trees on the ground.

If an acre of ground contain a certain quantity of organizable matter, and 4840 trees are planted at one yard asunder, each tree obtains a proportional part of it; if half are taken away, each tree will obtain a double portion and grow so much the quicker, and a tree of thirty inches circumference will be of more value than two trees making the same quantity of wood jointly. As a farmer would calculate how many head of cattle his pasture will keep, so may I calculate how many trees my land will support. A little learning is said to be a dangerous thing, and I know not that it can be more applicable than in the observations made to me by some few with whom I have conversed, viz., that trees will bring up each other when planted close. I will not deny this position as to a certain number of years, but afterwards they will inevitably try to kill each other, and generally succeed. Trees may be kept crowded or apart, according to the object aimed at in their cultivation,—as for hop-poles, or as saleable underwood; but I must be always understood to speak of raising *timber*, and it is that alone for which I use my pen. I observed, for many years a plantation of two or three acres, near Blackburn, in Lancashire, principally composed of Spruce and Scotch firs, planted at three or four feet apart,—which were allowed to remain at the same distance,—and perhaps

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eight or ten yards high: these had drawn each other up to their ruin: a high wind broke in upon and laid them nearly level with the ground: the axe was then put in requisition, and the plantation is now no more. This must be the fate of a great number in England. I heard a gentleman once assert that full three-fourths of the young trees of the present day will never arrive at maturity. A nobleman in my own neighbourhood has observed to me, that he had great pleasure in planting, but could not give orders to cut them away; this, I fear, influences many others, and is a most mistaken clemency. One very great evil I will mention as most destructive to a wood; it is admitted that when the trees are too close, many ought to be taken out; but the owner refuses to do it because wood is selling at a low price, and year after year he allows his trees to remain injuring each other; he would, however, add more to the value of the estate if he cut a number out and allowed them to rot on the ground. Another vile practice I will here name: the owner of a wood wants money, and directs his agent to cut down some wood, who obeys his master's directions, and cuts away the best trees, those which will produce the most money being always the most healthy and thriving. In this way I have known one wood treated, which exhibits at this day a most miserable spectacle.

There is, perhaps, no greater hindrance to the proper management of plantations than game, particularly where it is the hobby of the owner, who rides it full gallop. A hobby, Sterne has said, is the most useful animal in the world, so long as the owner only rides it at a gentle canter. I might as well get permission to pull down the mansion as to enter with the axe one of these pet covers, which are generally, when arrived at twenty years of age, so crowded and drawn up that they are little better than hop-poles, and, having no underwood, cease to be even good covers for game.

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Here, then, is a two-fold disadvantage,—no cover for game on the one hand, and on the other the trees are not arriving progressively at timber, whereas by the contrary management both would have been obtained. When a wood is thinned, having been previously neglected, the trees that are left standing being suddenly exposed to the blast, often give way: if they do not fall, they are wind-shaken: the owner might at once take them down, since there is not any way to support a tree of thirty or forty years' growth effectually.

A certain portion of underwood is considered of great utility to trees, by facilitating their growth, keeping them fresh and healthy, and their roots moist and warm; and should a tree be destroyed by lightning, or in any other way, another may be reared. I have observed often that where the bole or stem of a tree had previously been covered with moss, and some neighbouring trees were taken away, some leaves then came from the stem: could any one doubt this being a signal of improved health? A clean skin is most essential to health either in vegetable or animal. When a plant breathes it makes use of its skin, since it has not any mouth, and through all parts of its skin where it is green, air is flying off and rushing in incessantly. All that a plant wants is a little food which is supplied by water with a small quantity of common soil, and *plenty of light*. A plant rejoices in the light; it feeds fast, it digests, and a thrill of delight, as it were, passes through it when the sun's beams first strike it in the morning after a long night's rest. Compare only the rich green leaves of the forest glade with the weakly slender starvelings that are stretching upwards in the gloomy shadows of choking plantations! I think it the most beautiful thing in nature to see the sun glimmering through the trees full of life, splendour, and joy; the underwood, even to the fern, apparently participating in the genial influence. Trees should not be nearer to each other than to allow the underwood to grow up

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underneath; there should not only be fine trees, but also, I may say, children and grand-children rising up to supply their places when vacant by death: where underwood will not grow, I will venture to affirm that the trees are too near each other. I have never given a tree so much room that I have had occasion to repent of it; it has increased so much in bulk that I have been induced to use the axe with even more freedom the following year. In cutting out trees I profit in two ways,—first, by the value of the trees I take away and sell; secondly, by the greatly improved value of those which remain on the ground. Where all are allowed to remain as they were planted, there is present loss and future ruin. After thirty, or sometimes fifty years, they will only continue to exist so long as they assist and support each other. Divested of their lateral branches and leaves, they are deprived, as it were, of their lungs, and are barely kept in a lingering state of existence by the few top-most shoots, that in the struggle for life have forced their way to the light. When at this age some are taken away, the remainder—long consumptive-looking poles—if able to stand, only drag on a miserable existence, but most likely fall an easy prey to the first blast.

The healthy tree thrusts out its roots in greater number and to greater distances, and is thus enabled to extract nourishment from a greater extent and depth of soil than can ever be reached by the sickly plant; it expands larger and more numerous leaves, and can thus extract from the air a greater quantity of the food which is fitted to supply the wants of the living vegetable. It must be obvious, that if plants are closely crowded together, their roots must go to the same place for nourishment, which they will soon exhaust, and therefore become more or less starved, while their branches and leaves, by continually interfering, must prevent the free circulation of the air. When a number of young

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trees are planted, they require a certain portion of organizable matter for their support, and as trees increase in size they require more nourishment; but at the time they require more, men give or allow them less; and if all remain on the ground as planted, how is it possible that they should ever become timber trees? how can any animal get fat without plenty of food?

In Professor Henslow's opinion, the power of ramification inherent in the roots is the most beautiful instance of design that we meet with in so fertile a field as that of vegetation; it compensates for their want of power of moving from place to place; but, when trees are crowded, this power is very much circumscribed. The principal roots may be considered as the great arteries which convey the sap to the stem, and the small fibres as indispensable auxiliaries, with their thousand mouths running in every direction, sucking in all the fluids which present themselves, and conveying them to the principal roots, whence they are passed into the stem.

Planting and subsequent management of trees are totally distinct, though both are essential to ultimate success. Many gentlemen there are, I firmly believe, who think there is nothing more to be done after the tree is put into the ground; and the rewards given by the Society of Arts in the Adelphi have been premiums given for the greater number of trees *planted*, without any regard to their after cultivation.

Another and main consideration is the leaf. If trees stand too near to each other, they cannot throw out leaves sufficient to obtain support from the air; the tops only being exposed to the light, are drawn up, and the trees, if not thinned out, become too tall to be supported by the strength of their bole.

During the day, and while plants are exposed to the influence of the light, carbonic acid is absorbed by them, and decomposed, the carbon alone being retained in their structure while the oxygen is given off. During the night, and

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when light is withdrawn, this process of decomposing carbonic acid cannot go on. Plants, therefore, can only derive nourishment when, in consequence of the influence of light, they are able to effect its decomposition. When trees are too crowded, and so close to each other as not to receive any light, do they not live in perpetual night, never able to decompose and receive any carbon, without which a tree cannot prosper? A branch from an apple tree was separated, and introduced into water connected with a mercurial gauge when the leaves were upon it: it raised the mercury by means of the ascending juices to four inches; but a similar branch, from which the leaves were removed, scarcely raised it a quarter of an inch. The use of carbonic acid in the atmosphere seems to be in affording nourishment to plants. It is formed during fermentation, combustion, putrefaction, and respiration, and a number of other operations taking place on the surface of the earth, and there is no process known in nature, by which it can be destroyed, but vegetation.

The food on which vegetables live enters by the roots and leaves of plants; the leaves under the influence of the sun decompose the carbonic acid, and give off its oxygen and retain its carbon, and the carbon unites with the elements of water in the sap, and forms those several compounds of which plants chiefly consist. Plants, it would appear, are destined by Providence to purify the air, which is loaded with carbonic acid from the lungs of animals, and give out a fresh supply of oxygen to replace what is taken up by the lungs of animals. The influence which the evaporation of the leaves has on the whole atmosphere, as well as on the whole earth, produces very extensive effects. The French complain that with the diminution of their forests, their vineyards suffer.

When the leaves of plants are accidentally wanting at a period when their presence is necessary, as for example, if,

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for a particular purpose, they are stripped off a tree when in a growing state, as is done in the mulberry, or if the hail destroy them when the tree is in full vigour, a vital phenomenon ensues which partly repairs the injury; all the latent buds in the axils, which would not have been developed till the following year, grow very rapidly and form new leaves, and if by any particular circumstance this phenomenon does not take place, the tree usually perishes. Vegetables effect many changes in the food they take up through the leaves; as when many different kinds of fruit are produced by grafts from the same stock. All distribution of the leaves is connected with the functions of the organs; and in order that the action of each may be properly performed, it is necessary either that the leaves be far apart from each other, or that, within a given distance, they cover each other as little as possible; in fact it will be seen that in all the different systems of the position of the leaves, it results that those which arise immediately above the others, never exactly cover them—in the least favourable cases the third covers the first, and the fourth the second; in several others it is the sixteenth or sometimes the fifteenth or twentieth which covers the first. Leaves, in presenting to the winds two resisting surfaces, more or less considerable, tend to produce an almost continual agitation in the branches of trees; and we know from some beautiful experiments of Mr. Knight, that the branches facilitate the progress of the sap and the growth of the trunk: trees with large leaves grow more rapidly, and serve for the secretion of different juices.

I have so long dwelt upon the leaves to impress upon mankind, if possible, their value, and the more so considering that they are in general scarcely thought of *any value*. Every leaf bears a bud in its axil, and every bud the rudiment of a new branch. The bud is placed at the summit of a fibre, and communicates with the medullary sheath by the medullary

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rays at the summit of which it is situated, and communicates with the woody fibre. It was only in the last century, when Priestley led the way to the discovery of the constitution of the air and other gaseous bodies, that any thing approaching to correct ideas respecting the nature of vegetable substances was entertained. We are in general too forgetful of the air, yet it is of the greatest importance to all our daily occupations, even to life itself, both vegetable and animal. So far from encouraging timber to grow, man does all in his power apparently to prevent it; he keeps, for instance, all on the ground as they were planted; and as if that were not sufficient, he prunes off all their branches and leaves, and deprives them of the power to obtain their own living.

It may not be considered inappropriate if I here mention some of the giants of the forest in England. There is the Cowthorpe Oak, in this county, within eight feet of the ground 16 yards in circumference: when compared with this, all other trees are but children: it is reputed to be 600 years old. There is the Queen Elizabeth Oak, at Huntingfield, in Suffolk, which cannot be less than 500 years old. The ash may be styled the Venus of the forest, from the lightness of its foliage, the graceful sweep of its branches, and the silvery appearance of its stem: there is one at Woburn, 90 feet high and 16 feet in circumference, at three feet from the ground. The Tortworth Chesnut, mentioned by Evelyn; above 1000 years have rolled over its green head. There are the fine old remains of a magnificent tree at Cobham, in Kent, 29 feet in circumference, three feet from the ground; its exact age—a point always of difficult and uncertain determination—is conjectured to be about 1000 years. The Lime tree in Moor Park, Hertfordshire, whose age is not exactly known, has a circumference at three feet from the ground, of 17 feet 6 inches. The Chippenham Elm, at Chippenham Place, Kent, is 15

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feet 8 inches in circumference, at three feet from the ground. The Crawley Elm on the road to Brighton, measures 61 feet in circumference at the ground.

A stately forest is one of the grandest sights in the creation, and an insulated tree the most beautiful.

> Hail! old Patrician trees, so great and good,
> Hail! ye Plebeian underwood.

No tree in all the grove but has its charms, and each its charm peculiar. There is again the Shelton Oak, or Owen Glendower's Observatory, on the road side near Shrewsbury. Mr. Billington presented to Her Majesty two oak plants grown from the acorns of this tree, which are planted in the gardens at Buckingham Palace. The Duke of Athol's larches, at Dunkeld, are known to every one in that part of Scotland; they have grown upwards of 80 feet in seventy years. Twenty of them, when felled at the age of sixty-four years, exceeded 100 feet in length each; and in another instance eleven of these trees were sold for £150 to ship-builders. In short, according to a calculation of the Duke's agents, an acre of larch would eventually produce considerably above £1000. We have, I believe, about thirty millions of unprofitable and uncultivated land in this kingdom, and if even half of them had been planted, a century ago, we should have been independent of all foreign supply, and the national debt would almost have been annihilated. I cannot omit to mention the Welbeck Oak, known by the name of the Duke's Walking Stick, now blown down, and the Passenger Oak, 19 feet in circumference, recalling to the mind Virgil's description of a similar object,—

> Quæ quantum vertice ad auras
> Ætherias tantum, radice in Tartara tendit.

The duration of the British oak is almost incredible. I took out of Ethelbert's Gateway, at Reculvers, in Kent,—now all but tumbling down,—a piece of oak that had been walled

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in with the original building, and cutting it with a knife, found it apparently sound, when the bricks were crumbling to pieces. I have read a description of the oak—

Three centuries he grows, and three he stays
Supreme in state, and in three more he dies.

Sir Robert Walpole planted with his own hands many of the magnificent trees now the pride of Houghton, and of all the actions of his life, this was one which seems to have given him the most gratification in the performance, and the most pleasure in the retrospect.

More free from peril than envious Courts.

Cicero mentions planting as one of the most delightful occupations of old age; and it is indeed of all pursuits the most disinterested. He who puts a sapling into the ground is morally certain he shall never live to enjoy the shade of its matured branches; but he enjoys it every day in the thought that the land, which to his predecessors had been only a barren waste, will present to his successors a scene of waving beauty. Plantations, ultimately woods, present many advantages, and are yearly arriving at greater and still greater perfection and value, so long as man lives. The encouragement of trees is not only a pleasing but a very valuable amusement: it is also a virtuous employment, particularly from the love we ought to bear to our country and posterity. I am aware that some will ask, what might be made of so much money put out to interest, with compound interest, in fifty years? I answer, that at the end of fifty years the planter or his son will receive the additional value with all other incidental advantages; and think how well time and money have been expended, proving a source of wealth to their families, and contributing in the mean time to some of the most rational and refined enjoyments of life.

No one has carried agriculture and arboriculture to greater perfection than the late Earl of Leicester, better

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known as Mr. Coke, of Holkham, whose estate, when he came into possession of it, was little better than a rabbit warren. I have been through some of his woods, in company with his agent, who observed to me, in passing through one for which, fifty years ago, Mr. Coke could not get two shillings and sixpence an acre, that rather than take that small sum, he planted it; and I will venture to assert, that at the time of my observation, the crop of wood was worth one hundred pounds per acre, the trees being about five yards apart. What a very small part of this sum would the accumulation of rent, expense of planting, &c. amount to! not at the utmost to forty pounds, for interest and compound interest; and from this sum should be deducted the profits arising from the trees taken out and sold in that period. At Wells, the neighbouring seaport, I saw a vessel chiefly built of timber raised from acorns of his own planting.

I could mention also instances where the female sex have not considered this subject beneath their notice; and had life been spared, one illustrious and talented lady, most probably, from the unwearied anxiety with which she sought after practical knowledge, would have made more valuable communications, and obtained more golden medals. Long will the Duchess of Rutland be remembered by the Royal Society.

The landowner who plants, provides, as it were, a sinking fund to resort to, should any event occur to demand an extraordinary expenditure. The accomplishment of so good an example may be realised by arrangements which require but little annual expenditure or land taken from his rental; and if in an exposed situation, may be made to give additional shelter to the land adjoining. Shelter is not, I think, sufficiently valued: it greatly assists to produce good herbage: these are substantial advantages, added to the incidental ones of beauty of scenery, &c. By the judicious planting of hedge-row timber on an estate, it may be thrown into a kind

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of garden, that may turn out as much to the profit as to the pleasure of the owner. "Nihil homine libero dignius."

I speak of timber cultivation, and all gentlemen would wish, whether at a distance or in the immediate neighbourhood of their mansions, that their trees should become stately ones. Old timber, like old walls, commands respect.

Branches seem to be the means of producing and maintaining a certain quantity of leaves, which act in a way easier to conceive than define, in attracting the sap upwards, and through them a communication is kept up with the atmosphere, from which they collect their carbon; and every increase in the size and number of their parts is attended with an increase of nutritive power, and a further development of new branches and leaves. I may be allowed to state generally that a tree, divested of a considerable portion of its branches and leaves in the growing season, vegetates slowly; and I would desire any one to attend to the fact, that the more abundant the covering of healthy foliage may be, the faster the tree will progress. Mr. Billington has given tables of experiments on the growth of several kinds of forest trees in girth, &c., to which tables, in his publication, I would refer my readers who wish for more accurate information.* He endeavours to ascertain the utility and best mode of pruning, or other management, to promote their growth. He takes a larch, for instance, with the branches entire, (as will be seen on reference to his tables), which was found to have increased two inches and one-eighth in girth, in each year, for four years on an average; and a second, with branches shortened, increased two inches and four-eighths each on an average; while another tree, with the branches cut close to the stem, to four and five feet, has only increased one inch and three-eighths, or a very little more, each year. These

* To the publication of Mr. Billington, of Underhill, I am much indebted, and having the pleasure of knowing him, I value his work the more.

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trees grew together in the same soil, when Mr. B. had the management of one of the royal forests. This second division shows the difference very clearly between the two modes—between cutting off the branches close to the stem, and leaving them to nature. The tree with the branches cut close, in four years had increased three inches and three-eighths; the tree with the branches cut off had a little the advantage of the best soil. The tree with the branches *entire* had increased seven inches and three-eighths in four years, making one inch in each year more than the other—an object well worth attending to. Mr. Billington has divided his tables into sixteen divisions, giving the result of different modes of treatment to which I will recommend all intelligent foresters. I will now contrast this conduct, which from my own knowledge I have every reason to believe to be good, with the practice of those who are advocates for murdering nature. Some there are, who, not content to do all possible injury with the axe and the saw within the command of the tallest man, seek the aid of a long pole with a chisel at one end; one man directing the fatal instrument, and another, with the aid of a large mallet, striking the blow, and cutting away all branches within reach, thus reducing trees to so many magnificent fishing rods. I would ask, how are these trees to get their living, when, in addition, they are crowded so close together that they have not room for pasturage with their roots, and the little food they do obtain they cannot digest for want of leaves, which the ignorance of man has deprived them of?

If the owners of woods, to whom I have referred, were to live to double or treble the age allotted to man, they could never make timber trees from these scare-crows, thrown back in their growth *many, many* years. Narrow belts of wood produce generally only sickness and decay. Trees in hedge-rows thrive better than those in narrow belts,

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because from their situation they acquire roots, branches, and stems suited to them; but trees in narrow belts, from being in a thicket while young, acquire great length of stem, but roots and tops proportionally small, so that when thinned out, from the narrowness of the belt, they become exposed nearly as much as in the single row, and therefore become sickly, from a delicacy of constitution unsuited to this exposure, and from a deficiency of roots to draw moisture commensurate to the increased evaporation.

The extension of the root is inversely as the induration; rapid while it remains herbaceous, but slow as it is converted into wood: hence moisture and shade are the circumstances of all others the most favourable to elongation, because they prevent induration, or retard it. Mr. Knight shows that timber is produced, or rather the sap-wood is rendered ligneous, by the motion of the tree during the descent of the sap. It is also shown that the solid texture of the wood greatly depends on the quantity of sap, which must necessarily descend, and also on the slowness of the descent. Both these requisites are materially increased by side branches, which retain a large quantity of sap by their junction with the stem, and occasion a contraction or twisted direction of the vessels which obstructs the progress of the sap; the maple and birch which have fewest side branches, bleed more freely than any other. These hints afford additional evidence against pruning; any deformed branch may be taken off without dressing up trees like broomstieks.

The forest pruners may stick to their axes and saws and pruning hooks, spite of nature, reason and argument: I will on the present occasion, in obedience to nature and reason, try to prove by argument, both theoretical and practical, the truth of the maxim, "Prune not at all, if you can help it." The subject only requires a little observation, conducted with common sense. The most inveterate of weeds may be killed

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by depriving it of its leaves; you also kill a young oak by the same process. Take two plants of any sort; prune one freely and the other sparingly, or not at all; the effect on the stem of each will show clearly how essential are branches and leaves to promote the growth of the stem.

In botany, the talent and labours of inquirers have generally been spent in the examination whether a plant belongs to this class or that order; neither chemistry nor physics, the most powerful means of help to conquer prejudices and acquire knowledge, have been allowed to sit in council on the examination of the most simple processes. The size of a plant is proportional to the surface of the organs which are destined to convey food to it: a plant gains another mouth and stomach with every new fibre and every new leaf. Culture increases the annual circles of the wood; but common injudicious pruning tends to diminish them, and merely extends the stem in length by throwing all the new formation of branches to the top of the tree; thence the tree acquires a slenderer figure and a more delicate constitution, from greater height; and being without cover of side branches, loses more by evaporation and receives less moisture from the ground. The principal process of vegetation, (assimilation by the leaves) being reduced by pruning, and carried on under a diminished supply of nourishment from the ground, is less productive of new assimilized matter, and this smaller quantity requiring to be extended along a greater length of stem, the annual rings are necessarily thinner. A forest tree, perfect in all its parts, has been compared to a well-regulated mixed government; the bole or stem representing the monarch, the larger branches the nobility, the smaller branches the gentry of different degrees, the leaves the people, and the roots the laws on which the whole fabric rests. Pruning, let it be observed, is itself a violence done to the plant, and call it by what name you will, all pruning is mutilation, and to

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be avoided as much as possible. Pruning does not increase the quantity of wood, for the operation has directly an opposite tendency and effect. Use the knife in a state of infancy, and give the tree that form which is calculated to produce the greatest quantity of timber in the proper place, and remove only branches of that size which will heal over during the summer. Trees properly thinned always produce the best, cleanest, and soundest timber; and as in men we look for soundness of principle, so in timber we look for soundness of wood.

I have before said that I do not approve of any branches being taken off, except those which can be taken away early with the knife: the blemish produced by pruning large branches is too great to be compensated by any advantages. The gigantic whip handle given as a frontispiece to Pontey's Forest Pruner has done, in my opinion, incalculable mischief. I have read observations relative to the comparative advantages of close pruning and snagging, and were I compelled to adopt one, I should prefer the plan of close pruning. But is pruning or lopping at all necessary, except in a state of infancy, or in particular ornamental trees to please the eye? If the increase of sound timber is sought after, then I do think pruning more likely to defeat the object than to attain it. It must always be remembered that there is a reciprocity between the roots and branches. In whatever proportion you lessen the head by lopping, &c., in like proportion you lessen the power of increasing the bulk of the stem, in destroying the balance of reciprocity. Foreshortening a branch is the best mode to adopt, provided it is done at such a distance from the stem that the branch is kept alive; for, if you cut so near as to endanger life, and it dies, you must choose between the blemish of a close cut and a long snag. The wounds produced by amputation may be concealed, but cannot be healed, it being an axiom in physiology that should

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ever be kept in view in the consideration of this subject, that live tissue cannot form any organic union with that which is dead: I have various specimens of wood to prove it. Plants are never healthy, except when their stems are clean; and in order to bring that to perfection, I know not any mode so effective as the admission of sun and air. I have effected it with my own. Where sun and air are denied, that parasitical plant, moss, will grow: light and air will kill this moss, and the tree will push out fresh twigs and leaves, a sure and certain sign of health. Evelyn recommends rubbing and washing the boles, but this must be very limited in its operation with a forest; and even it be once done, it will be necessary to do it again the next year; but if sun and air be admitted, it will not be necessary. I have kept my own trees as they were planted for a few years, until they had acquired good upright stems—the object sought after by pruning—and when I have brought them to that state, I then commence cutting away, to enable them to swell out into wood; and my trees being at the distances of three, four, and five yards from each other, they have acquired root-hold to defy all blasts. Though a difference of opinion may exist as to the profit to be actually realized, enough is shown, I think, to prove that a liberal expenditure in planting, and subsequent management, will be amply repaid with interest and compound interest to the family, by the increased growth of the trees, and all other indirect and incidental advantages. These are, the cubical feet of wood—the beauty—the shelter to adjoining land in a mountainous district—the shelter to the domain—as well as affording covers for game; these advantages are sufficient to induce every one to plant; and besides, a well timbered estate more readily finds a purchaser.

It has been said that "England expects every man to do his duty," and I know of no better mode than planting and taking care of oak trees. The office of Surveyor of Woods

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and Forests is one of more than ordinary responsibility, having duties attached to it of the greatest possible consequence; yet, from the reports made to Parliament, I have great reason to fear it is not managed to the utmost advantage.

Having previously stated that I resorted to books in vain, I will here mention the names of some, in which the authors profess to give calculations as to profit, &c. First, in a book written by a man of the name of James Sawyer, with the title of *Growing Gold*, it is said that because the forests in America grow so near each other as to exclude the sun, ours ought to do the same. In page 72, he says "that trees should stand close together, and meet at the top." In page 137, he adds, "the practice of thinning large trees brings destruction to those "which remain." If trees grow close together, I agree with the author that, having been previously crowded together, no tree could stand when its neighbour was taken away. At page 41, he says that "where tops of trees press against each "other through each wood or plantation, individual trees receive "but a trifling share of wind, and the *outside trees* are sup- "ported, so that few, if any, receive injury in the roughest gales. "This natural defence is a complete answer to the system so "generally practised by modern wood agents, of admitting light "and air to the stems of trees; it is quite clear that such a "measure is not required." The author states that the outside trees are supported, but he does not say how. I will inform Mr. Sawyer, that having access to light and air, they are consequently stronger than the rest; and had all the trees received the same advantages of light and air, they would have been equally strong. He also says, he is surprised that "they who are entrusted with the care of plantations should "have omitted to make themselves acquainted with the manner "in which trees grew spontaneously in the ancient woods, and "should have adopted, without any inquiry, an artificial "system at variance with every principle of nature." Does

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Mr. Sawyer mean to say that the fine oak and ash, in a park or hedge-row, is not a tree in a state of nature? and that the park and hedge-row timber are not more valuable than the trees in American forests, touching each other at the top, the only part on which the *sun ever shines?* A young man could not, in my opinion, read a more dangerous book.

A Mr. Withers, of Holt, in Norfolk, has published in his works a table, the plan of which I do not find fault with, provided his calculations were correct; but it is of these I complain. He states that an acre, at the end of sixty years, would yield a profit of £1300. He then goes on to state,—"As a found-"ation for my calculations, I took the tables of Mr. Waistell; "and I did so because I know not of any other published state-"ments of the produce of woodlands, and I trusted to his great "experience for their correctness." He adds,—"I reckoned "on thinning each plantation, as recommended by Mr. Wais-"tell, so as to leave trees at distances from each other equal "to *one-fifth of their height.*" From the above statement he has professed not to have any knowledge of his own, but to have borrowed from Mr. Waistell. He then goes on to state, "I completed my table, and the results obtained were "a gain per acre, at compound interest, *on my plan*, of £6435. "With a view of drawing the public attention to so important "a subject, I determined to publish my table immediately;" and he *actually says* that a considerable number "was printed "and orders sent for advertising it, when I received a letter "from Sir Thomas Beevor, to whom I had sent a manuscript "copy of the table, in which he stated, and proved to my "satisfaction, that forest trees could not grow to the estimated "extent, nor without injuring each other, so closely together "as Mr. Waistell had allowed them, for Sir Thomas's letter "was accompanied by a table of *twice the distance.*" He then states that he remodelled the tables according to the suggestions of Sir Thomas, and thus improved, lays them before

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the public. What can I, what can the public think of this gentleman's judgment? He has not, in my humble opinion, any real knowledge. Had it not been for Sir Thomas Beevor, he would have imposed upon the world, or endeavoured to do so, to this extent, that in sixty years an acre of land would have yielded £6,435, and 500 trees upon an acre, at one-fifth their height distance.

Then comes a Mr. Monteath, who published a book, and called himself the King's forester. He says, that "for the "sake of such of my readers as have not an *opportunity of "seeing Mr. Withers' book* and table, I give it a place in my "Forester's Guide;" and adds, "it is the most *useful* and "interesting table I have ever seen." He moreover adds, that "it is no uncommon thing to see a tree, at forty years "old, worth £3; and no uncommon thing to see a plantation "at that age bearing more than 500 trees, at the distance of "ten feet, worth that sum." That a tree of that age may be worth £3, I will not deny; but I do not believe that there can be 500 of them on an acre. This "king's forester" adopts all the errors of Waistell and Withers. What advantage can possibly be obtained by consulting Sawyer, Waistell, or Withers? I cannot see any. I do see great disadvantage to an inexperienced person. *No one will be able to grow gold by their advice.*

With whatever disrespect I have mentioned some books, there are others which I must name as worthy of attention, although not to the exact point of my subject. Evelyn's Sylva; De Candolle on the Organs of Plants; Duhamel sur l'exploitation des bois. The latter mentions that the small end of a branch attracts the sap or moisture from the earth with nearly as much force as the large end; and that force is very little in a branch stripped of its leaves, but greater when the tree is furnished with leaves: that every thing which creates an obstacle to perspiration diminishes the force of suction; and

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on the contrary, all circumstances which are favourable to perspiration increase the power of suction. I cannot here give his diagrams and reasoning more at large; but they who wish to read more know where to go for that information.

In arboriculture, as in other sciences, nothing can be permanently effected in a moment. Time does not spare what is done without him.

This is, no doubt, a valuable society, which embraces the collections of individual research. It is in the power of this society to inform a man of the value of his estate, geologically speaking. A few months or years accomplishes the task: as flint and steel produce fire, so the collision of different opinions determines a disputed point in the arts, and elicits the truth. An architectural society requires little time to mature and bring to perfection disputed points relative to the origin of the Gothic arch. With sovereign power, a building may be reared in a very short time, but I do not know of any human power to raise a tree in the same time, which from a state of infancy is an object of great interest, and promises great future reward; and what is it that constitutes the great value of our existence, but that hope? Why do such societies as the Agricultural Society exist, but for the benefit of the nation at large, and through them to effect more than can be done by private individual exertions? All the above can be proved in the life-time of man. If to advance the different sciences, societies of men are formed, how much more is one required to encourage the science of arboriculture, which demands time beyond the age of man!

Can any consideration be more momentous than to find out the best mode of cultivating the oak, the pride not only of England but of the world? Can any horticultural produce be more beautiful than the wild forest tree? it bears its flowers as well as the common garden plant. A society of this kind

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can only, I think, succeed under the patronage of men of rank and large property, and with the protection of government. From it reports might be made from time to time, and issuing from a body of men incapable of deception, it would have the desired national good. Such society I am ready at any time to join. If an Arboricultural Society was once formed, it would not be a difficult thing, I would hope, for that body to range the royal forests, and obtain pecuniary assistance from government; to direct observations to be annually made as to the growth of different kinds of trees — their distance from each other—their circumference—and when any were taken down, to preserve transverse sections, from which it would be calculated what interest they were paying—and in addition, to receive reports from private individuals, from time to time.

Money may be acquired in mills, factories, &c. &c.; but agriculture and arboriculture improve property, in untold ways, without inflicting any one evil on mankind, or the brute creation, and delight the man of taste. The increase of forest trees does not bear any proportion to their destruction. Men are in general sufficiently alive to their own interest, provided the matter is fully demonstrated, which has not perhaps been hitherto done. How often has it happened that when any wood has been ordered to be cut down, the owner has expressed great surprise at its value, so little idea have men in general of its actual increase!

Finally: this subject I would name as a kind of moral virtue, which recommends itself by the pleasure that attends it. Nothing can be more delightful than to entertain ourselves with prospects of our own making, and to walk under the shades our own industry has raised. The restless activity of the mind of man leads it to require some object on which its powers may be exercised, without which it preys upon itself, and becomes miserable. If I am incorrect in anything which I have stated, I shall be glad to be told of it, so that

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at some future opportunity I may correct what may be proved to be erroneous. I shall continue to plant and transplant, till the Almighty shall, I hope, transplant me to a better world: this is an unweeded garden.

I may be thought to have laboured too long to prove propositions which no one can reasonably dispute; yet so incalculably important is the subject, and so comparatively indifferent is the attention of proprietors, that it becomes a duty still further to illustrate it, and prove its value even to the satisfaction of avarice itself. Words written and statements made may not be credited by all, but I am anxious that my premises should not be disputed or even doubted.

> Segnius irritant animos demissa per aures
> Quam quæ sunt oculis subjecta fidelibus.

I have caused some engravings to be made from nature, from which any gentleman may make his own calculations; and I have given a table with the diameter, circumference, and area of a transverse section, by which he may calculate what per cent. his wood is making; and if he allows his trees *any room to grow*, he will be most agreeably surprised by an increase of 15, 20, 25, and even as high as 30 per cent.*

To those who have inherited plantations I would appeal. They ought to tend with care the object of their ancestors' solicitude. No document is wanting to show what was their will, as every tree so planted is a living evidence of the interesting fact. It is obvious that a planter's principal care must have been the wish of benefiting posterity. He must have felt gratified in contemplating the shelter and worth which his work was adding to the domain; and that posterity must be truly ungrateful, which thwarts or defeats this benevolent design. One argument against planting, and that weighs heavily with proprietors who are advanced in life is,

* See Table at the end of this Report

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that they will not live to see the trees become ornamental to their estates, far less to reap any benefit from them. Evelyn, in his "Sylva," mentions a story of Maximilian the Second, who, finding an old man setting date trees, asked him what his meaning was, in planting a tree which required so many years before it bore fruit? "Sire," replied the old man, "I have "children, and they may have more come after them."

Thos. Sopwith, Esq., F.G.S., exhibited a model of the strata near the coal and iron works at Ebbw-vale, Monmouthshire, the property of Messrs. Harford, Davis, and Co., in which the workings of the successive beds were accurately laid down, and could be inspected with the greatest ease.

Dr. Buckland said that whoever saw such a model as this, could not fail to understand the nature of a coal field. Now that we had the means, it would be a sin on the part of the nation to neglect the opportunity thus afforded for making an accurate register of the state of our mining districts. If such registers had been kept of ancient workings in the principal coal-fields of England, they would have been the means of preserving the lives of hundreds of miners, and have prevented the loss of an immense amount of property. Before sitting down he begged to move the thanks of the meeting to the authors of the Papers, and to Mr. Sopwith for his explanation of the model.

Sir Francis Lindley Wood seconded the motion, which was carried unanimously.

The thanks of the meeting were then given to Earl Fitzwilliam for his kindness in taking the chair.

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TABLE REFERRED TO AT PAGE 71.

Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.
5	15.7080	19.6350	7⅞	24.7401	48.7070
⅛	16.1007	20.6290	8	25.1328	50.2656
¼	16.4934	21.6475	⅛	25.2555	51.8486
⅜	16.8861	22.6907	¼	25.9182	53.4562
½	17.2788	23.7583	⅜	26.3109	55.0885
⅝	17.6715	24.8505	½	26.7036	56.7451
¾	18.0642	25.9672	⅝	27.0963	58.4264
⅞	18.4569	27.1085	¾	27.4890	60.1321
6	18.8496	28·2744	⅞	27.8817	61.8625
⅛	19.2423	29.4647	9	28.2744	63.6174
¼	19.6350	30.6796	⅛	28.6671	65.3968
⅜	20.0277	31.9192	¼	29.0598	67.2007
½	20.4204	33.1831	⅜	29.4825	69.0293
⅝	20.8131	34.4717	½	29.8452	70.8823
¾	21.2058	35.7847	⅝	30.2379	72.7599
⅞	21.5985	37.1224	¾	30.6306	74.6620
7	21.9912	38.4846	⅞	31.0233	76.5887
⅛	22.3839	39.8713	10	31.4160	78.5400
¼	22.7766	41.2825	11	34.5576	95.0334
⅜	23.1693	42.7184	12	37.6992	113.0976
½	23.5620	44.1787	13	40.8408	132.7326
⅝	23.9547	45.6636	14	43.9824	153.9384
¾	24.3474	47.1730	15	47.1240	176.7150

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MR. HAMERTON'S PAPER ON ARBORICULTURE.

EXPLANATION OF THE PLATES.

Having given a table of diameters, circumferences, and areas, advancing by $\frac{1}{8}$th of an inch in diameter, any one may be enabled to know how soon, by a certain annual increase, a tree will double itself in quantity of wood,—as the area of 5 in. diameter would be 19.6350, of 7 in. 38.4846, which area, multiplied by the length of the stem, will give the solid contents.

PLATE I.—A horizontal view of the growth of wood: some of the circular spaces are shaded to assist the eye in distinguishing more readily one from the other, and the more easily comprehending the dimensions; circles being to each other as the squares of their diameters. The tree must advance in the respective proportions to enable it to double its previous bulk; and it will be for any one to ascertain how many years' growth of his trees will be required to make up the requisite number of inches in diameter necessary to obtain double wood: if the diameter be two-eighths of an inch on each side of the circle—four-eighths in the whole diameter—then the tree would make the 2 inches required in four years,—paying 25 per cent. On the other side I have given a vertical section of the same: at the bottom of Plate I, *b*, I have given a magnified specimen of an oak, to show the cellular as distinguished from the fibrous tissue. The cellular is the first wood grown in the year, and the weakest part of the wood; in quick grown wood the fibrous tissue is much larger and stronger, and it is proved that the one will bend when the other will break. The answer given by Mr. Andrew Knight to the question of Lord Glenbervie, viz., whether oaks which grew in poor soil and slow, were of a firmer nature and more durable timber than when grown in a richer soil? was—"No. Their timber is more porous, lighter, and less durable; a layer of very porous wood marks the commencement of each year's growth, and when the growth is small these porous layers almost touch each other," (as in the specimen I have given of oak marked *c*, *Plate III.*) The experiments of Professor Barlow, at Woolwich, prove the same. Two specimens of oak were selected, one from a fast grown tree and the other from one slow grown: two pieces were squared down to 2 in., and were broke on props 50 in. asunder; the one from the quick grown specimen deflected 1-50th of its length, with 660 lbs., and was broken with 999 lbs.; the other, the slow grown, deflected 1-50th of its length with 414 lbs., and was broken with 667 lbs.

PLATE II.—I have given a tree to show some branches I think proper to cut off. The two branches marked A A, which rival the leader, I would only shorten, leaving two small shoots to keep alive the branch. At B there is no other mode to be adopted but that of removing this branch by a close cut. At *b* is given an example of a branch having been cut off many years before, and no union having taken place internally with the new and the old wood, the fact, however, being concealed by the bark outside; when such a tree is cut down, the old and the new separate immediately. I have a great many specimens to prove this. On the back of this Plate, I have given four plants, two as first planted, 2 feet high and 4 feet apart, which are the usual proportions. The two tall trees at the same distance, neglected for perhaps fifteen or twenty years, and from 20 to 30 feet high: if the distance of 4 feet was proper at first, it cannot be so always.

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PLATE III.—*a.* Fine piece of old oak from the ruins of York Minster, in which the fibrous tissue is very large. This is, perhaps, one of the finest pieces of oak ever seen, and must have been part of a very large tree, the annual increase in diameter would be ¾ of an inch.—*b.* A piece of ash of a very rapid growth, and equally as fine a specimen.—*c.* A piece of oak taken from the ruins of York Minster, of very slow growth, scarcely two-eighths of an inch in diameter: in this the cellular rings would be very near to each other, and consequently the wood weak.

PLATE IV.—*c.* Is a section of a fir taken from a crowded plantation, which will give a good general idea of what I wish to enforce, viz., that in the early stages of a plant's growth, it may find sufficient space and food for its support; but as the plant increases in size, a struggle for nourishment commences, which increases in severity, and finally terminates in the destruction of the weaker by the stronger plants, but not until after a contest which leaves the survivor stunted in its growth, and the soil exhausted by having had to support many plants instead of one. That this specimen has suffered from such a struggle is shown by the gradual diminution of the years' growth.—*b.* A section of a larch in a good prosperous condition, averaging ¾ of an inch in diameter.—*a.* A section of a larch in Gisburn Park, which was blown down in 1839. This tree stood alone, and the annual increase is almost one inch in diameter—perhaps without precedent: the first Lord Ribblesdale told me he brought it in a pot from Italy. This tree contained 200 cubic feet.

PLATE V.—*a.* Section of an Athenian poplar of gigantic growth, at the rate of one inch and a quarter in one year, also the same in the following year. —*b.* Section of the Scotch wytch elm, averaging ¾ of an inch in diameter in each year,—good growth where a tree has room allowed.—*c.* Section of an ash of very slow growth, in which the cellular rings are very near to each other; this is very weak poor wood, when compared with the fine specimen which I have given in *Plate III. b.*, and would bend or break with a less weight.

If any one will apply the compasses to the specimens I have given of the oak, ash, larch, &c. &c., they will be surprised at the result of their calculations, and these engravings are all taken from nature. I can only give one side of the circle, double of this will therefore be the diameter. I will finally add what is reported to have passed very recently in Parliament. Sir Robert Peel is said thus to have expressed himself—"Mr. Deacon Hume, in speaking of the timber, said, "you have plenty of iron and coal, and your true policy is to take active mea-"sures to possess wood."

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Fig a.

PLATE. I.

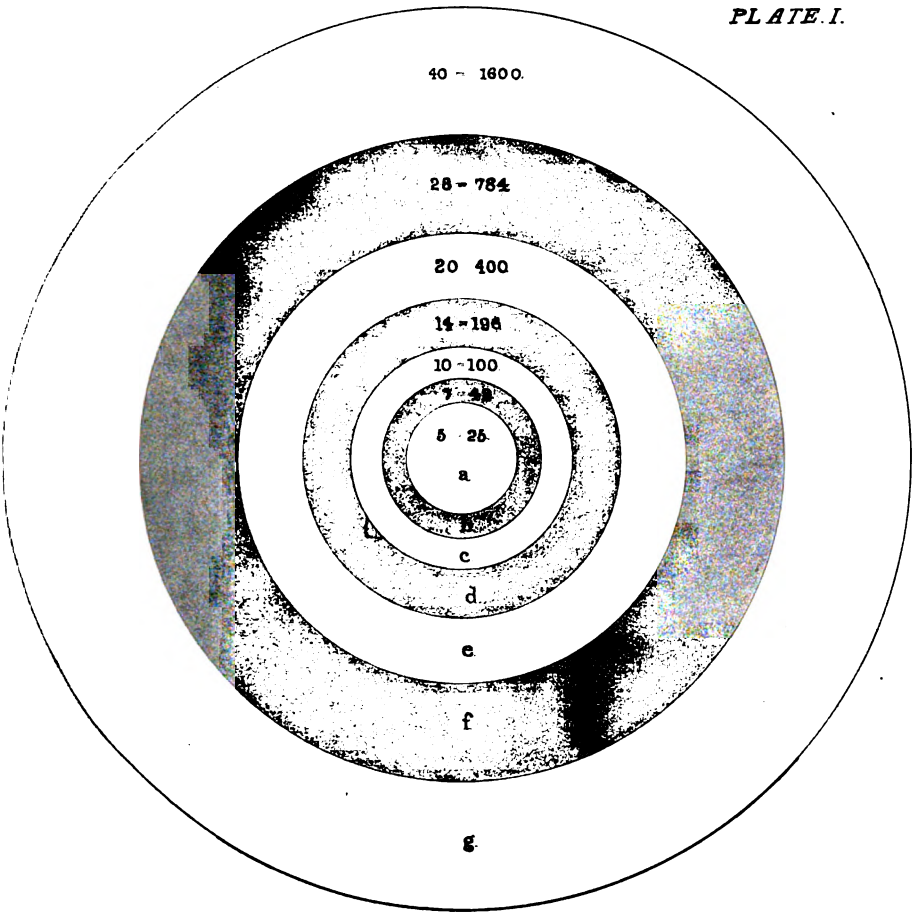
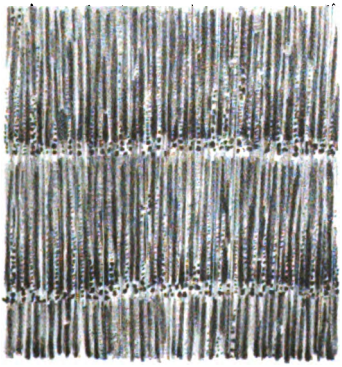


Fig b



Magnified Oak

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AREA

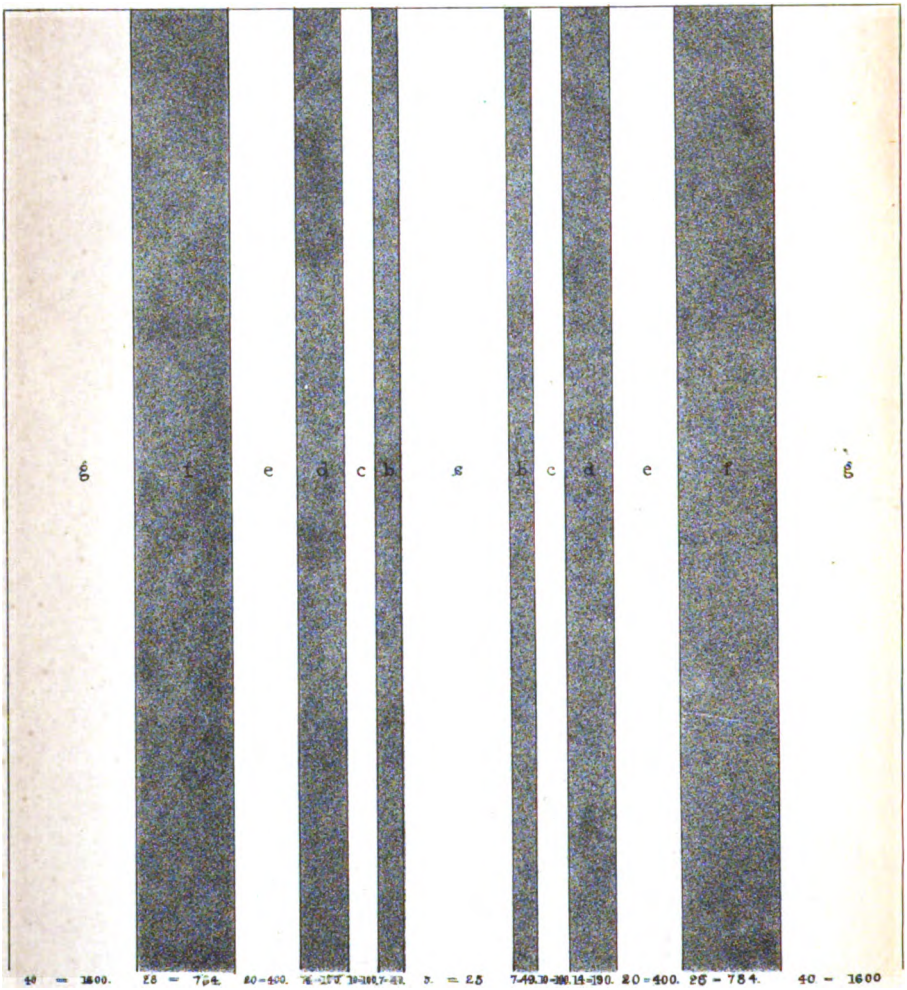

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Fig. a

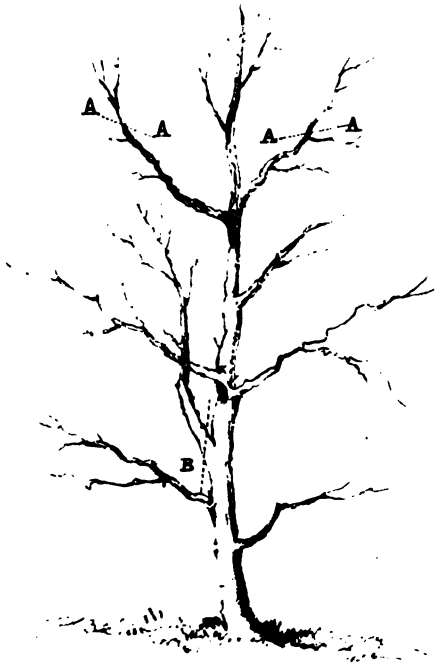

Fig. b

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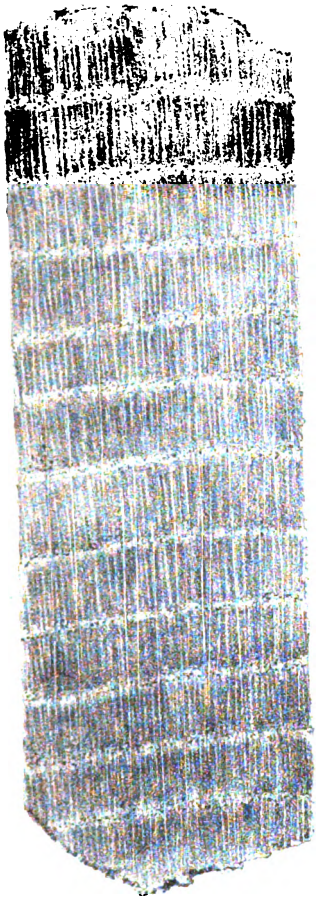
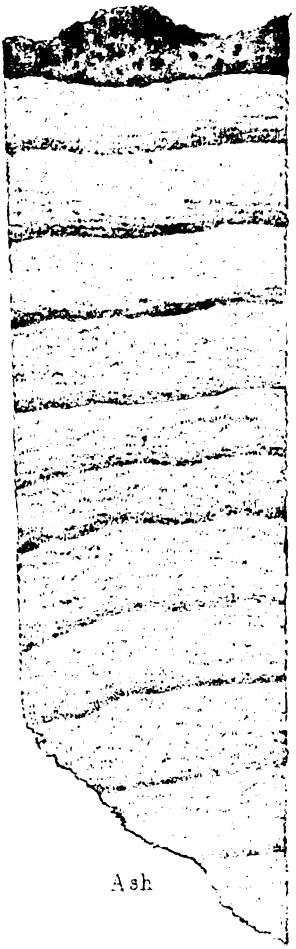
a



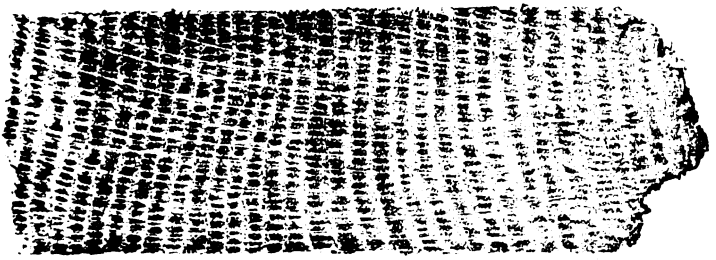
Oak

b



Ash

c



Oak

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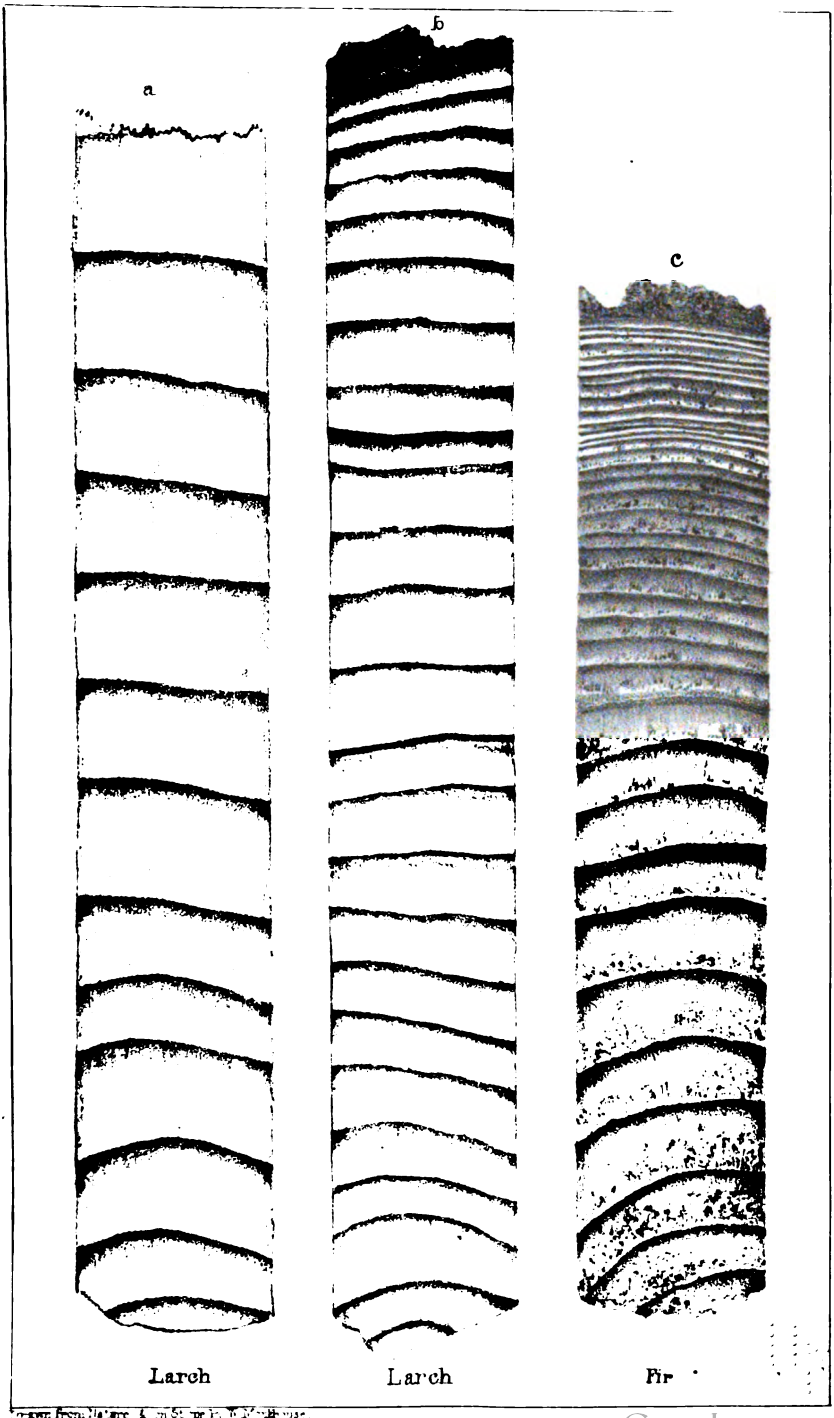

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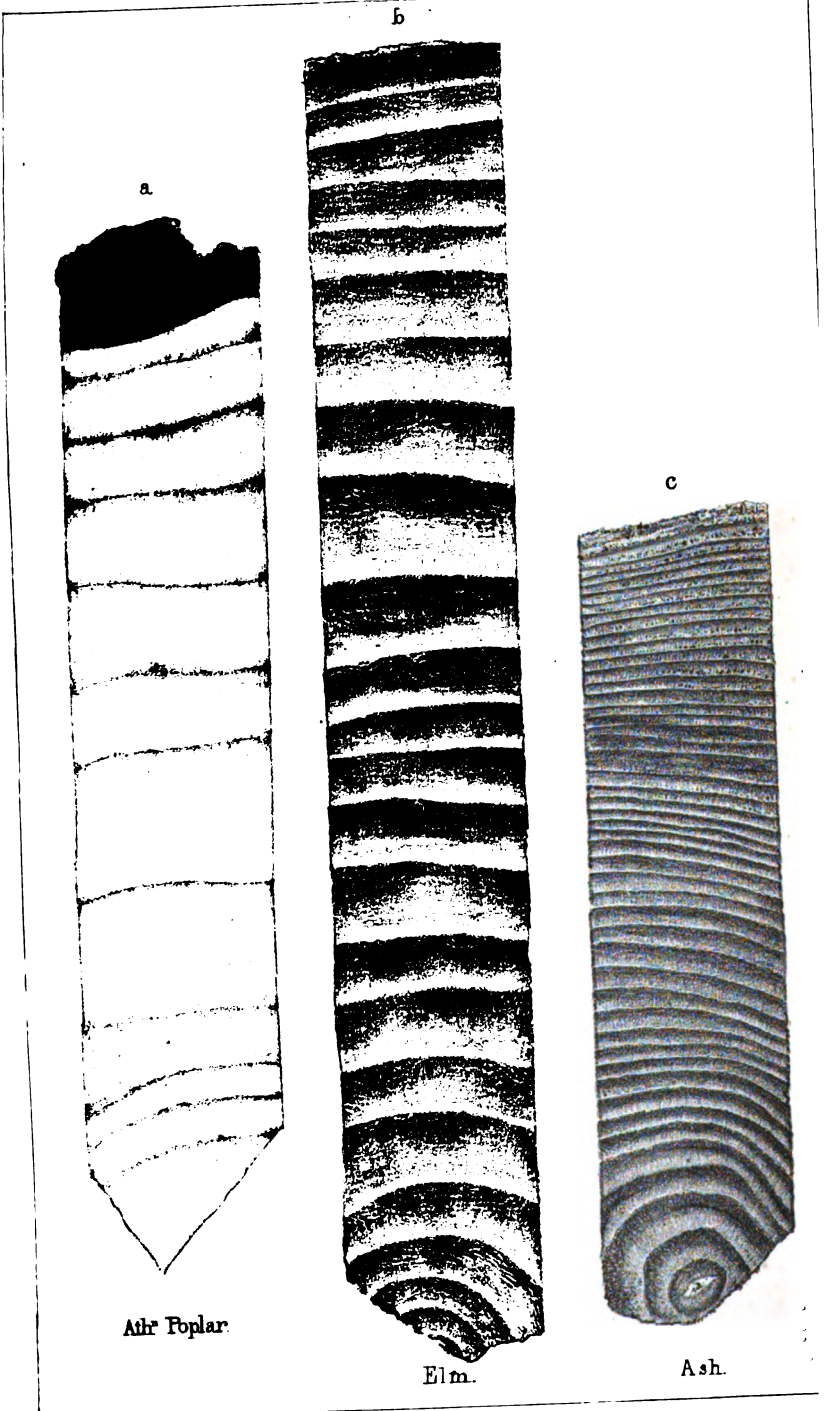

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE TWENTIETH QUARTERLY MEETING, HELD IN THE EXCHANGE ROOMS, BRADFORD, ON WEDNESDAY, 14TH OF DECEMBER, 1842.

On the motion of HENRY LEAH, Esq., seconded by HENRY HARTOP, Esq., the Chair was taken by the Rev. W. SCORESBY, D.D., F.R.S., Member of the Institute of France.

The Rev. Dr. SCORESBY then rose and said,—in introducing to their consideration the objects of the meeting, a very few words on the present occasion would serve for that purpose from himself. It would be in the recollection of most then present, that that was the second meeting in Bradford of the Geological and Polytechnic Society of the West-Riding of Yorkshire. It was, however, the twentieth quarterly meeting which had been held by the members of the Society, circulating in different large towns in the West-Riding of Yorkshire, so that in turn it came there to hold its meetings. It might just be necessary to explain to those who might not be acquainted with the origin of the Society, what its intention and objects were. With regard to this, he might observe that the objects were summarily and comprehensively contained in the designation of the Society—

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"The Geological and Polytechnic Society of the West-Riding of Yorkshire." In all its transactions it was highly practical. It was one of those institutions designed to bring out scientific principles, and to make them bear on the practical objects connected especially with the commercial and manufacturing interest of the West-Riding of Yorkshire. As the causes which had very much increased the property of the Riding were connected, not only with manufactures, but with mining, geology became very important. Every one must be aware who had attended at all to the enterprise of penetrating the surface of the earth, that very large sums had been expended, or rather wasted, by reason of the want of the information which geology could most distinctly have imparted. For though geology, as a science, might be considered imperfect, and ever would be, inasmuch as the distance they could penetrate beneath the surface of the earth must always be an extremely small proportion of the whole, still the knowledge obtained by geology was in many respects perfectly certain; so that negatively, at least, we could in many instances satisfactorily anticipate what might *not* exist beneath the surface of the earth. We could not, indeed, in every instance, predict in unexplored parts of the country all that lay hidden beneath the surface: nor, that because the surface *might* consist of certain strata favourable, for instance, for coal or iron, could we in every case predict with certainty that there *must* be coal or iron. But we could in very many cases predict, from the nature of the surface, and that most positively, that there could not be either coal or iron-stone there. Hence, a mere negative decision by geology, on a question of such interest, became extremely important, as at once setting aside the temptation to useless and expensive enterprise; and, on the other hand, geology, generally speaking, so far afforded positive knowledge as to show whether such substances as coal might be reasonably expected in any

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particular district. Here, then, the objects of the Society became very practical and exceedingly important, as connected not only with the resources of the manufacturing districts, but also with the economy of the property of those who were disposed to speculate in developing the hidden treasures of the earth. Further, the Society contemplated the consideration of matters connected with the improvement of mining and agricultural operations generally, together with objects of philanthropy, in respect to the health and safety of persons employed in those various operations. It belonged to this Society, according to the scope of its plan, to investigate circumstances affecting the lives and well-being of miners, whether by gases liable to explosion, or by air deleterious to human life. Thus, a mere statement of them must show that all the objects of the Society were eminently important, because they had a practical bearing on the prosperity of that portion of the country in which they had their habitation.

The SECRETARY then read the following names of gentlemen desirous to be admitted Members of the Society :—

Mr. STATTER, Wakefield.
MATTHEW HALL, Esq., Wortley, near Leeds.
JAMES GARNETT, Esq., Bradford.
CHARLES WALKER, Esq., Bradford.
ROBERT MILLIGAN, Esq., Bradford.

These he proposed should be admitted Members, which was seconded by J. G. HORSFALL, Esq., and carried.

At the Evening Meeting,

J. O. BUTLER, Esq., Kirkstall Forge, and
W. LYTHALL, Esq., of Bradford,

were proposed and admitted.

Mr. WALLEN proposed a vote of thanks to the Local Committee and to Mr. Edward Hailstone, the Local Secretary. Mr. H. HARTOP seconded the motion, which was carried.

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JOHN RAND, Esq. moved the following resolution:—That the thanks of the Society be given to Godfrey W. Wentworth, Esq., for his donation of fossils; to Henry Briggs, Esq., for his donation of fossils and granite boulders from the valley of the Calder, near Horbury; to Mr. William Lee, of Sheffield, for his donations of three slabs of flagstone, with impressions of fossil footmarks; to Henry Belcher, Esq., of Whitby, for a valuable collection of fossils from the lias and oölite; and to Mr. Leyland, for fossils from Stoodley Pike, near Halifax.

The Rev. W. TURNER seconded the vote, and in doing so he might perhaps claim the privilege of a stranger, in suggesting to the gentlemen of Bradford and its vicinity, that the Museum of the Society was remarkably deficient in specimens connected with this particular locality. He thought it highly probable that many of the gentlemen then present, and others, who he hoped would favour them with their attendance before the close of the meeting, had an opportunity of supplying this deficiency. He thought this a most important locality. The motion was then put and carried.

The Rev. CHAIRMAN then rose and said, that, different from the order announced on the card and circular which had been handed to them, he had been requested to give his communication in the first instance, which course he should adopt. He then commenced the delivery of his communication, which was not written, but spoken extempore. He said the subject announced as his communication was—

AN EXPLANATION, WITH ILLUSTRATIONS, OF A PRACTICAL METHOD OF DETERMINING THE QUALITIES OF IRON AND STEEL, AND THE DEGREES OF HARDNESS OF THE LATTER.

This subject would, he trusted, be felt to be of some practical benefit, when considered in connection with the very

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extensive and important iron works in this parish—when connected with iron works, the produce of which bore such a very high character, and always fetched such very high prices in the market. The principle which he had to submit to them bore on the determination of the different qualities of the different numbers or kinds of cast iron and malleable iron, as produced from the different ores in the neighbourhood. In order, however, to render the subject intelligible, and the process satisfactory, he thought it would be useful to develope in the outset the *principles* upon which the mode of determining the qualities of the different substances were founded; for the methods of inductive science required that they should, at all events, be enabled to see some relation between the cause and the effect, the means and the end. Thus to place in some measure before them the principles connected with the mode of determining the qualities of iron or steel, it would be necessary to state a few particulars with respect to the nature of the magnetic principle on which the determination depended. The magnetic principle, it should be observed, was merely a secondary principle, and not a principal agent. It was an attribute of one of the great agencies which the Creator had appointed for subjecting the material and physical creation to his will. They found that all physical substances in nature were endued with certain properties, and subjected to certain laws: as, for instance, two particles of certain bodies, possessing variety but affinity of nature, could not be brought together without combining, nor, when united, without producing a total change in the quality of the resulting substance. Thus, two substances, in themselves acrid or corrosive separately, or each possessing noxious properties, by being brought together might combine and become harmless. In bringing them together there was a certain mysterious agent engaged, of the original and essential nature of which we are ignorant—only knowing

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something of its secondary characters, as developed in the attributes or effects of that great agency. When they combined dissimilar substances, such as a drop of acid, and a drop, in solution, of an alkali, they had chemical action, and a change in the nature of the substances, from their original elements. This change came under the denomination of chemical action, and was, apparently, one of the influences or effects of the mysterious agency he was speaking of. And when this took place there was very generally a change of temperature—heat being frequently evolved. Change in electric condition also took place; and a great development of electric action was another of the effects. At the same time there was an exhibition of magnetic phenomena. All these developments, it seemed, arose out of the operation or action of some great agent with which they were unacquainted. No doubt it was of that mysterious kind which never will be understood, nor ever could be apprehended by our present faculties, excepting so far as we learnt and knew its effects on different material substances. It was an agent which came a step nearer than those comprehensible to us, to that Great Being who was infinitely mighty and mysterious. In every substance in nature, whenever a chemical change took place, there was a development of magnetic phenomena. The magnetic principle, if he might call it a principle, which in popular language he might do, abode in every substance in nature—in a piece of wood, or a piece of brass, or silver, as well as in iron. Proof of this was had in the fact to which he had alluded, that whatever produced chemical action in any substance, developed something of magnetic phenomena. If they placed a piece of any kind of metal between the poles of a galvanic battery, so that it formed a conducting medium between the zinc and the copper, it became instantly magnetic. There was very little difference between the magnetic energy developed in one metal and

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another. The electric, or galvanic, and the magnetic principles were inseparable, the characteristic difference being that they flowed (considering them as currents) in directions at right angles to each other. In the neutral state in which they generally were, very few substances in nature exhibited magnetic influences. A piece of glass had the magnetic principle residing in it the same as iron, but it did not exhibit the magnetism, nor would the proximity of a magnet excite or develope it: it was invisible to any test whatever. If they took a piece of brass in the same way, under ordinary circumstances, they could not produce any magnetic change in it, unless they brought it within the circuit of the galvanic apparatus, or exposed it to the action of heat or chemical change. Thus in the brass, the magnetic influences that are there can be developed; at the same time, when it is separate from such action, it exhibits no magnetic property whatever. There was one substance, however, which did, as every one knew, exhibit this property in a very striking manner and degree. A piece of iron was capable, by mere proximity to a magnet, and still more so by contact, to exhibit very powerful magnetic phenomena. This was the case in different degrees with all ferruginous substances, whether in ore or in a metallic state, as malleable or cast iron, or steel. Whatever was the nature of the combination of iron, it generally had some capability of exhibiting magnetic phenomena.—There were other substances, not ferruginous, which had the same properties, but in so slight a degree that it was not necessary now to consider them. It perhaps might be well at that stage to show the nature of the development of the magnetic property in iron; because that matter would bear immediately on the subject that he wished to illustrate. He had there a piece of iron (holding a small bar in his hand), and if he brought it into proximity with the powerful magnet before him, not close, but even at the distance of two or

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three inches, it would become magnetic, and able, as they observed, to sustain a large key weighing 2,300 grains. They saw the effect produced by this action of the magnet, but now [removing the iron away from the magnet, and applying the key again,] there was no magnetism on it, and it was just as indifferent to the key as before. This was not by reason of actual transmission of anything from the magnet, that the iron became magnetic—not by reason of anything put into it that it did not contain before; but it was the development of latent or neutral principles—as might be illustrated by reference to the case of a smith who took a cold piece of iron, and with skill could beat it until it was red hot, as was frequently done, and so that he could light his fire with it. In this case, the blacksmith did not put into the iron any heat that was not there previously, because his anvil and his hammer were cold; he merely developed by the peculiar condensation of the substance of the iron a certain quality of the iron which had previously been latent in it. So, applying this illustration to the magnetic question, this analogy was found—they did not put anything into the iron, they only called forth the latent or neutral principle within it. This was one condition that referred to the object he had in view, and which bore on the method of determining the qualities of iron, as they would see in a short time. He might now enunciate another fundamental principle in his processes for determining the quality of iron—that whereas ferruginous substances generally were capable of the magnetic condition, those most perfectly ferruginous, or of the purest iron, were capable of the highest development of magnetic condition. If he brought a piece of cast iron to the magnet, it would be found that it exhibited the magnetic character in a much inferior degree to that which malleable iron did. He might show that a piece of steel would exhibit it, by mere contact, in a slighter degree than iron. [Dr. Scoresby took a piece

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of steel and placed it beside the magnet, after which it suspended a small key.] There was there a less tendency to get magnetism by juxta-position than in iron, but there was a greater tendency to retain it. For whilst the iron lost its power by removal from the magnet, the steel did not. The more imperfect the iron, as in ones having perhaps one-third or two-thirds, or five-sixths of earthy substance, or the more it was in a state of oxide—the less were its capabilities for showing the magnetic action. If they took cast-iron, they would find a susceptibility of the magnetic influence, but in a degree of capability very different from that of malleable iron. If they took malleable iron, of a quality pure and soft, they would find the highest capacity for the magnetic condition. Now, when he discovered that any portion of ferruginous substance in a body rendered that substance capable of magnetic development, and when he knew that malleable iron generally exhibited that in the highest degree, then he drew the inference that that which was most perfectly iron would show the highest development of the magnetic condition; and, therefore, that the iron which should exhibit the highest magnetic capabilities would be the best quality of iron. There were two methods by which, on these principles, they might determine the quality. [The Reverend Gentleman then placed upon a stand a magnetic needle or compass, having at the end a small graduated card as a scale. He then took up a small flat magnet and two small flat pieces of iron.] He had there two pieces of iron from the Bowling Works. They were marked B and L—B being the mark for the best iron, and L iron of the lowest quality. He had also a superior steel magnet of the same size. [He then opposed the magnet steel bar to the compass at some distance, and placing in succession upon it the iron plates B and L, he found that the needle receded from the magnet with L upon

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it further than from B, though placed at equal distances.] Thus upon the principle that he had asserted, the B iron, which fetched the highest price in the market, and which cost more in the manufacturing, appeared, from its greater neutralizing effect on the magnet, to be a more perfect quality of iron, to have less crude matter in it, or to be more purely ferruginous than the other. For, just as he had anticipated, the bar B proved to have higher capabilities of magnetic influence than the bar L. In order to ascertain this more conclusively, he had got half-a-dozen plates of each kind of iron made, so as to get a mean result, which would be more accurate than that obtained from a single specimen. To illustrate his method of determining the capacity of the several plates of iron for magnetism, as shown by their respective neutralizing action on the steel magnet of like dimensions, the Rev. gentleman showed that the action of the magnet alone upon the compass, at the distance of 15 inches, produced a deviation in the needle from the proper meridian of about 20 degrees, or two such magnets together of 31 degrees 15 minutes. Having, with the series of iron plates kindly furnished him by the managers of the Bowling Works, placed each of them in succession betwixt a pair of small magnetic steel plates, he found the average effect at the same precise distance to be, that the plates L reduced the action of the magnets on the compass to 8 degrees 21 minutes, and the plates B to 6 degrees 45 minutes; so that the mean reduction of power (the measure of the magnetic capacity) by L was 31 degrees 15 minutes—8 degrees 25 minutes=22 degrees 50 minutes; and by B was 31 degrees 15 minutes—6 degrees 45 minutes=24 degrees 30 minutes. Thus showing that the best iron had decidedly the highest magnetic capacity, and that the magnetic capacity of each kind had an analogous relation to the respective values of these two articles in commerce.

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J. G. HORSFALL, Esq. inquired what difference was found in the different bars of the best iron?

DR. SCORESBY said they were extremely uniform in the best iron; not one specimen of that kind came anything near the inferiority of the other. The difference did not exceed in any case 33 minutes of a degree; not the third part of the distance between the two classes. He then went on by the application of another principle to investigate the quality of *cast iron*. For that purpose he had obtained six or seven sets of the same size of the two extreme qualities. One consisted of the best quality of cast iron, the other was of inferior quality. They were of the qualities usually marked 1 and 3. There might be a considerable variety in No. 1 or 3; but the difference between 1 and 3 was sufficiently characteristic. There was also a considerable difference betwixt the two classes in price, as well as quality. No. 1 had less oxygen and a larger portion of carbon than No. 3, being of a purer description. Without going particularly into the chemical constituents of iron, he might just observe, that as the best quality of iron had in the other case the highest magnetic principle, he expected he should in this case of cast iron find a similar law. He treated it, however, in a different manner. He got the plates cast in the same way in "green sand," so that they should be very hard, and might exhibit more of the nature of steel. His plan was to try them by magnetising them and converting them into real magnets, being of opinion that as the best steel produced the best magnets, so the best cast iron would produce the best magnets. His first experiment was by magnetising them separately, and then carefully trying their powers by the compass. One kind, No. 1, had the power of causing the compass to diverge, on an average, 13 deg. 41 min., while No. 3 only caused it to diverge 10 deg. 7 min.—the difference between the two being as 136 to 100. Thus it appeared that the best

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cast iron had a power about one-third greater than the power of the inferior. But he tried it another way. Having found that the accumulating magnetic capabilities of substances, in relation to their number, became another test of quality, he began to try them one upon another, taking the exact quantity the compass diverged after each addition. He put a second of the best quality, and found that the divergence of the compass was about 18 deg., while No. 3 was only 12 deg. 30 min. Six plates of the best cast iron thus combined produced a deviation of 25 deg. 47 min., while the inferior only produced a deviation of 17 deg. 44 min., being 8 deg. less than the deviations of the best series. He did not mean to say that the theory was established on which this principle of testing cast iron was founded: it would require many more experiments: but yet so far as his experiments had gone, the object he had in view was fully realized, for it had been shown that they could detect quality by a scientific mode without breaking into metal—they could discern the different qualities in the kinds he had compared to a nicety, equal to that which would be shown by weighing 15s. in gold and a sovereign. He next proceeded to the application of the principle to the determining of the quality of steel. He believed that there were really no scientific means established besides that which he had suggested, of determining the quality of steel generally. The methods in use consisted in the exercise of that sort of knowledge which arose from constant mechanical practice and observation; and the best judges of steel by these means were the men who worked on it. They estimated something of the quality by the appearance when broken; but they were not unfrequently deceived by the fracture. By this appearance they might suppose that a piece of steel was as good as possible—a beautiful quality—and yet when they come to work it into cutlery it perhaps would not do. Thus the working well and tempering well, with the

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appearance of the fracture, enabled the practical smith or cutler to obtain the best knowledge of the quality of steel. Now here he proposed to apply a scientific method for the determining of the quality of steel. With regard to wrought *iron*, it had been shown to have no permanent capabilities for retaining magnetic influence: it retained it so little that its retentiveness afforded no practical test of quality. When they tried steel, however, they found a certain permanency—no matter what might be the condition or quality of the steel, whether hard or soft, good or bad, it was capable of permanent magnetism. [He then took up two pieces of steel.] He had there a piece of steel of a very fine quality and very soft; he had given it the magnetic power. He had also another piece of steel of like quality, but perfectly hard, and it also was a magnet. Now herein steel exhibited a peculiar difference from iron in its magnetic properties. Iron was capable of more magnetism when it was in contact with a magnet; but steel retained it, on its removal from the magnet, whilst iron lost it. If iron would not retain the magnetic influence while steel would, he first came to this conclusion, that that which was most perfectly steel would retain the most power (that is, in like conditions of hardness), and that that which had the least carbonaceous matter in it would be the least permanent. He tried the supposed quality by experiments, and verified the principle. [He then took up a compass needle.] That was a needle, at one time in possession of her Majesty, which had been sent him for examination. [He then took up another compass needle.] That was also from the naval stores, and was by the same maker. [He then showed that the needles were magnets, by applying keys or large nails to them of different sizes, to ascertain how much they would lift. The one lifted much more than the other. He then took up a soft steel needle, one of his own, and showed that in that unfavourable temper it would lift more

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than one of the navy needles which was made of tempered steel.] On comparing his soft steel bar with the tempered navy needle, he found that his soft steel would lift the same or even a greater weight; hence he concluded that the steel of the naval needle was bad. But he also applied another test—the test of tenacity for the magnetic principle. He took a very powerful small magnet which he called a test bar, and applied the magnetised pieces of steel to it, similar poles of the test bar and of the bars to be tested being laid together. The quantity of power left showed the degree of tenacity which each had. [Dr. Scoresby then performed the experiment again. He put the first needle spoken of before (the inferior navy needle) on the magnet, a piece of glass intervening, and found on taking it away that the magnetic principle had entirely vanished. He then placed the second navy needle upon the test bar without the intervention of the glass, and on taking it off, it, too, was powerless. He lastly applied a needle of his own, and on taking it off it appeared not to have suffered from contact, as it still lifted a key about three times the weight which either of the navy needles could lift in their highest energy.] The first inference he drew from this was, that his bar was of a very superior quality of steel to the others, and the next was that one of the needles was utterly incapable of performing the function intended. In truth neither of them was sufficient for the objects for which they were used, as they could not adequately accomplish their purposes. The improvement of such sea compasses, therefore, was an object of national importance. To entrust a first-class ship of war, worth £100,000, perhaps, with a crew of several hundreds of men, to such instruments as these, involved a heavy charge of blame somewhere. He had now shown the meeting the vast superiority even of his single or ordinary needles over those of the navy: he had shown elsewhere, as well as here, that his

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mode of testing the quality would secure the best steel, and the best instruments, instead of risking a quality such as he had shown in one of the navy needles, which was not fit for a coach spring! Measures, indeed, had been commenced some years ago, after he had publicly exhibited some of his improvements in compasses, for improving those of the navy. He had shown his plans near four years ago to the gentlemen appointed for this object, so far as his investigations had then proceeded; but nothing effectual, he believed, had yet been done. Introductory to his process for the determination of the temper and hardness of steel, he should state that the principle had long been held that the harder the steel the more permanent the magnet. The truth of this he had tried in many experiments, and had always found it so. And now he came to the practical rule for knowing the hardness by the magnetic tenacity. If it was true that the hardest steel made the most permanent magnets, then it was only necessary to obtain a knowledge of the degree of permanency as the measure of the hardness. [He then re-magnetized two needles of similar quality, but different in hardness, and compared the weights which they respectively bore after being subjected to the action of the test bar;—when one had lost little, the other the whole.] Hence, he came to this conclusion—that the former was the hardest, which on trial by other means, was proved to be the fact. He then applied the test of the deviation of the compass, and showed also by this means that the hardness of the steel might be discovered with great minuteness: so that of 100 bars or plates of the same kind, as to quality, they could easily be arranged by the aid of the test-bar and compass, in the order of their respective degrees of hardness.

Mr. Morton inquired whether the bars must be always of the same diameter or of the same bulk, in order to carry out the experiment perfectly.

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Dr. SCORESBY replied that the experiments were, within certain limits, irrespective of bulk. He had compared steel of very different lengths, and had obtained (after application of an ascertained correction) very analogous results. But to save calculation, and to make the results more satisfactory, it was better that they should be similar.

The Rev. W. TURNER inquired whether they could depend on the test-bar—would it have the same degree of magnetism after a succession of tests, as at the commencement?

Dr. SCORESBY said, in order to determine that, he had ascertained the power of the test-bar before experimenting, and then after he again examined it, and if it had lost anything the experiment was not a good one. The test-bars he used were made on the principle of having them as hard as possible—and with the bar exhibited to them, great numbers of plates might be tested without any effect on the test-bar.

ALFRED HARRIS, Esq. moved the thanks of the meeting to the Rev. Chairman for his lucid explanation of the subject.

WILLIAM RAND, Esq. seconded the resolution, which was carried unanimously.

Mr. CLAY introduced to the notice of the company a beautiful geological model of the Forest of Dean, made by Mr. Sopwith, of Newcastle, for Professor Sedgwick, of Cambridge, and at the request of Mr. Clay, Mr. Morton briefly explained it.

The Rev. CHAIRMAN, in introducing the second paper, said, that it was with reference to the manufacture of iron by the hot or cold blast methods. The communication had reference to the hot blast side of the question. It would be read then, and the discussion upon it would take place in the evening. This appeared to be a matter of much controversy among practical men at present.

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Mr. CLAY, the Secretary, previously to reading the paper, gave a brief history of the controversy which had engaged the attention of the Society, and said, that at the quarterly meeting held at Wakefield in July, a paper had been read by Mr. Hartop on the different qualities of iron made by the hot and cold blast systems. Mr. Hartop was in favour of the cold blast, and it unfortunately happened that none of the gentlemen who approved of the hot blast attended that meeting to answer Mr. Hartop's arguments. He had now to bring before the notice of the meeting a communication from Mr. Graham, of the Milton iron works, and he much regretted to add, that the Chairman had received a note from Mr. Graham, stating that owing to ill health he was unable to attend and take a part in the discussion.

(Mr. Graham's Paper p. 92 et seq.)

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EXPERIMENTS UPON HOT AND COLD BLAST IRON

MANUFACTURED AT THE MILTON IRON WORKS.—(COMMUNICATED BY MR. W. GRAHAM.)

HOT BLAST.

	Size.	Blows.		Curvature.	OBSERVATIONS.
No. 1.	Rolled ..... $1\frac{5}{4}$ in. square.....	10	.....	$\frac{7}{8}$ in.	Neither heated nor swaged.
		50	.....	$2\frac{9}{16}$ „	No appearance of fracture.
		100	.....	$3\frac{9}{16}$ „	Section at bend $1\frac{9}{16}$—$1\frac{7}{8}$
No. 2.	Ditto ..... $1\frac{5}{4}$ in. square.. ...	10	.....	$1\frac{1}{4}$ „	Heated red and swaged till cold, reduced $\frac{1}{16}$ of an inch.
		50	.....	$2\frac{1}{16}$ „	No appearance of fracture.
		100	.....	$3\frac{1}{4}$ „	Section at bend $1\frac{9}{16}$—$1\frac{7}{8}$.
No. 3.	Refined ..... $1\frac{5}{4}$ in. square	10	.....	$\frac{7}{8}$ „	Neither heated nor swaged.
		50	.....	$2\frac{5}{16}$ „	No appearance of fracture.
		100	.....	$3\frac{1}{2}$ „	Section at bend $1\frac{1}{2}$—$1\frac{7}{8}$.
No. 4.	Ditto ..... $1\frac{6}{8}$ in. square.....	10	.....	$\frac{5}{4}$ „	Heated red and swaged till cold, reduced $\frac{1}{16}$ of an inch.
		50	.....	2 „	No appearance of fracture.
		100	.....	$2\frac{1}{16}$ „	Section at bend $1\frac{1}{2}$—$1\frac{7}{8}$.
No. 5.	Rolled ... ..$2\frac{1}{4}$ round	10	.....	$\frac{1}{4}$ „	Neither heated nor swaged.
		30	.....	$\frac{7}{8}$ „	No appearance of fracture.
		50	.....	$1\frac{1}{8}$ „	
No. 6.	Ditto ..... $2\frac{1}{4}$ round	14	.....	$\frac{5}{16}$ „	Heated red and swaged till cold, reduced $\frac{1}{32}$ inch full.
		21	.....	$\frac{7}{16}$ „	
		30	.....	$\frac{5}{8}$ „	No appearance of fracture.

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COLD BLAST.

	Size.	Blows.	Curvature.	OBSERVATIONS.
No. 7.	Rolled ... ..1⅝ square	5	.....	Heated red and swaged till cold—reduction 1/32 of an inch. Broke across at fifth blow.
No. 8.	Refined.....1⅝ square	1	... .	Heated red and swaged till cold—reduction 1/16 of an inch. Broke across at first blow.
No. 9.	Refined.....1¼ in. square.....	10	..... 5/8 in.	Neither heated nor swaged.
		50	... . 2 3/8 „	No appearance of fracture.
		100	..... 2 1/16 „	Section at bend 1⅝—1 1/16.
No. 10.	Rolled .....1¼ in. square.....	10	..... 5/8 „	Heated red and swaged till cold, reduced 1/32 of an inch—re-heated and allowed to cool gradually.
		50	..... 1 7/16 „	
		100	..... 2 9/16 „	No appearance of fracture.
No. 11.	Refined.....2¼ round	10	..... 1 7/16 „	Neither heated nor swaged.
		30	..... 7/8 „	No appearance of fracture.
		50	.. ... 1 5/8 „	
No. 12.	Rolled .....2¼ round	10	... .. 1/4 „	Heated red and swaged till cold.
		30	..... 1 „	No appearance of fracture.
		50	..... 1 5/8 „	

NOTE.—In making these experiments the bar was in each instance placed four inches over the anvil, and a hammer of 24 lbs. weight used in striking the bar.

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Copy of a Letter from Messrs. R. and W. HAWTHORN, Engineers, Newcastle-upon-Tyne, to GRAHAM and Co., dated November 29th, 1842:—

Gentlemen,—We beg to hand you the result of some experiments as to the changes produced in the strength of wrought iron in the process of manufacture into the various articles required by engineers; and, as part of the iron used is of your own make, we trust that these trials (from the suggestion of Jas. Nasmyth, Esq., in a highly valuable article published in the September Number of the Engineer and Architect's Journal, on the tenacity of wrought iron,) will not be altogether unacceptable to you.

Experiment 1*st.*—Hot blast railway axle from Milton Iron Works, one journal end heated red and hammered till cold, diameter of journal $2\frac{9}{16}$ of an inch; 6 blows fractured it, 3 blows more broke it clean off; fracture $\frac{3}{4}$ crystalized, $\frac{1}{4}$ fine fibrous iron.

Experiment 2*nd.*—The other end of the same axle, heated red and hammered till cold, then heated red and allowed to cool gradually; 100 blows bent it about three inches without the slightest appearance of fracture.

Experiment 3*rd.*—Hot blast $1\frac{3}{4}$ inch square bar from Milton Iron Works, heated red and hammered till cold, reduced to $1\frac{1}{2}$ inches square, laid 4 inches over the anvil:

10	blows	bent it	1	inch.
20	„	„	$1\frac{1}{2}$	„
30	„	„	2	„
40	„	„	$2\frac{1}{2}$	„
50	„	„	$2\frac{15}{16}$	„

Not the slightest appearance of fracture.

Experiment 4*th.*—The same bar, after receiving the above 50 blows, was turned over and nicked in the inside of the bend; 4 blows fractured, and 2 more blows broke it clean off; $\frac{3}{4}$ fine fibrous iron, $\frac{1}{4}$ crystalized, resembling steel.

Experiment 5*th.*—Cold blast scrap-iron bar from Messrs. Hawthorn's stock; bar $1\frac{1}{2}$ inches square; heated red and hammered till cold, reduced to $1\frac{5}{8}$ inch square:

6	blows	fractured it partly through.		
10	„	more bent it	$1\frac{7}{8}$	inches.
10	„	„	$2\frac{13}{16}$	„ Fracture $\frac{1}{4}$ through.

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Experiment 6th.—The same bar, after receiving the above 26 blows in Experiment 5, was nicked as in Experiment 4:

2 blows fractured it. } Fracture $\frac{3}{4}$ fine fibrous iron.
4 more broke it off. } $\frac{1}{4}$ crystalized.

Experiment 7th.—Hot blast bar from Milton Iron Works, $2\frac{1}{4}$ inches diameter; heated red and hammered till cold, reduced in hammering $\frac{1}{16}$ of an inch, laid 4 inches over the anvil; 50 blows bent it $1\frac{1}{2}$ inches. It was then nicked on the outside $\frac{1}{8}$ of an inch deep, and $1\frac{1}{2}$ inches round; 31 more blows produced a slight fracture of the finest and toughest character.

Experiment 8th.—Cold blast cable bar from Messrs. Hawthorn's stock; cold hammered, reduced $2\frac{1}{4}$ inches diameter, laid 4 inches over the anvil, as above; 50 blows bent it about $1\frac{1}{2}$ inches, no fracture. It was then nicked as in *Experiment* 7; 2 blows broke it square across, fracture quite crystalized.

NOTE.—The hammer used in these experiments weighed 31 lbs.

Copy of Letter from Messrs. R. and W. HAWTHORN, to GRAHAM and Co., dated December 8th, 1842:—

Gentlemen,—Our experiments on wrought iron already handed you, so far as related to your make, were exclusively confined to hot blast iron, but we have since added a few experiments on your make of cold blast iron, which we beg to hand you as follows, viz:

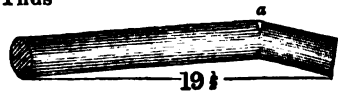
Experiment 1st.—Cold blast iron from Milton Iron Works, marked "C.B. Plate," bar $1\frac{3}{4}$ inches square, heated red and hammered till nearly cold, reduced to $1\frac{5}{8}$ inches, laid 4 inches over the anvil.

9 blows slightly bent it, } Fracture close crystalized,
the 10th blow broke it clean off. } resembling steel.

Experiment 2nd.—A bar of cold blast iron from Milton Iron Works, $2\frac{1}{4}$ inches diameter, laid 4 inches over the anvil.

10 blows bent it $\frac{4}{16}$ of an inch
10 „ more „ $\frac{7}{16}$ „
10 „ „ „ $\frac{10}{16}$ „
10 „ „ „ $\frac{12}{16}$ „
10 „ „ „ $\frac{14}{16}$ „

Thus



No appearance of fracture. It was then nicked on the outside as at *a* an $\frac{1}{8}$ of an inch deep, and $1\frac{1}{2}$ inches round.

2 blows fractured $\frac{1}{3}$ of the section, } Fracture crystal-
the 3rd blow broke it clean off. } ized.

NOTE.—The hammer used in these two experiments weighed 30 lbs.

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Further experiments made at Milton Iron Works :—

COLD BLAST.

No. 13.—Bar of refined iron 2¼ inches diameter, heated red and hammered till cold, nicked ⅛ of an inch all round. One blow broke it square off; fracture quite crystalized.

No. 14.—The same end of the last described bar, cold hammered, nicked ⅛ deep, ¼ round. Two blows broke it square off; fracture quite crystalized.

HOT BLAST.

No. 15.—Bar of refined iron 2¼ inches diameter, heated red, and treated precisely the same as the cold blast bar No. 13, nicked all round ⅛ of an inch deep. Sixteen blows broke it; the fracture full of fibre.

No. 16.—The same end of the last described bar, treated precisely the same as the cold blast bar No. 14, viz., nicked ⅛ of an inch deep, ¼ of an inch round. Nineteen blows broke it off; fracture full of fibre.

NOTE—The hammer used in these experiments weighed 24 lbs.

Mr. HARTOP requested permission to make one or two observations, and said, that the paper was no answer whatever to the one he had read six months ago, but instead of that, was merely a statement of experiments on the bending and breaking of iron after heating; in fact, the paper had gone into every position which it ought to have kept out of. With respect to the specimens of cold blast iron from Mr. Graham's, he would ask that gentleman's representative what time the furnace at which they were made had been engaged on the cold blast system, as it was a notorious fact that the Milton iron works were not cold blast works.

Mr. JUBB, of Mr. Graham's works, said, about three months.

Mr. HARTOP would take three months. Now, all iron-masters must know, that when furnaces were almost worked out by making hot blast, they could not produce cold blast iron from them worth having, if they were suddenly (or

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gradually either) changed from the one to the other. He protested against receiving the specimens under such circumstances.

Mr. LEAH said that three months would not bring the furnaces into a proper state.

Mr. HARTOP, in continuation, briefly stated the reasons why his paper was not read at the proper time. The discussions at the Sheffield meeting having taken more time than was anticipated prevented its being read there: at the following meeting at Wakefield no one was present to defend the other side of the question, and now Mr. Graham neglected to attend to support his views, and only sent a number of specimens of a dubious nature. He was glad the discussion had been put off till it came to Bradford, because the gentlemen connected with the iron trade here had discovered the fallacy of the hot blast system, and had had the moral courage to continue to make on the cold blast system, during a series of years of depression, the result of which was, that the miners in the vicinity of Bradford had been nearly fully employed throughout the three years, while the miners in other parts of the iron districts were only half employed.

The Rev. Dr. SCORESBY inquired whether the whole of the iron on the table was from the same iron works.

Mr. HARTOP: Some is from Hawthorn's, of Newcastle, and some from the Milton works.

Dr. SCORESBY: But it is understood that it is all from Milton produce.

Mr. HARTOP thought that a few of the specimens were not from Milton iron. He did not care, however, at what works the cold blast iron was made.

A long discussion then ensued, upon a suggestion made by Mr. Morton, of Normanton, that it was uncourteous to the hot blast defenders, to discuss the question when none of them were present, which ended in Mr. Morton giving notice

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that he should move its postponement to some future period, when they could be present.

THE CHAIRMAN requested that Mr. Morton would take the paper and make a condensation of it previous to the evening meeting, so that they might have it gone into regularly.

Mr. MORTON consented, and the paper was delivered to him.

The meeting then adjourned.

At the EVENING SITTING the chair was again taken by the Rev. Dr. SCORESBY, who called upon Mr. MORTON to give in his condensation of the paper read in the morning.

Mr. MORTON delivered the original paper, and stated that he had been unable to make a satisfactory abstract.

Mr. HARTOP then entered into a statement in defence of the cold blast system of making iron, and in the course of his speech detailed the following experiments :—

First,—Mr. Fairbairn's experiments, published in the "Manchester Memoirs."

Bars of 1 inch square and 4 feet 6 inches long between the supports :—

	Breaking weight.		Power to resist impact.
Oldbury cold blast iron	453 lbs.	.....	822 lbs.
Oldbury hot blast iron	534 „	.....	549 „

Using the same coal and iron stone :—

Elsecar cold blast	446 lbs.	.....	992 lbs.
Milton hot blast	353 „	.....	538 „

Working in the same mineral field in North Wales :—

Ponkey cold blast	567 lbs.	.....	992 lbs.
Plaskynaston hot blast	378 „	.....	517 „

The second experiment was also by Mr. Fairbairn, made with fifty sorts of iron, of which each bar of hot and cold

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blast iron were made of the same materials, and under the same circumstances. Cold blast iron with a load of 392 lbs. increased the deflection in 108 days from 1.786 to 1.84 inches. Hot blast ditto, in the same number of days, from 1.891 to 1.966 inches. Cold blast iron, with a load of 448 lbs., continued to increase in deflection, and ultimately broke after sustaining the weight thirty-five days. All the hot blast iron bars broke in the act of loading them with the above weight of 448 lbs.

The third experiment was by Mr. Todd, of Leeds, made between August, 1840, and February, 1841, and was abstracted from a paper by that gentleman, read before this Society at Leeds, in June, 1841.

		Breaking weight. Cwt.	Qr.
Bierley pig iron	No. 3. cold blast	25	2
Elsecar ditto	No. 3. ditto	24	0
Low Moor ditto	No. 3. ditto	23	2
Summerlee (Scotch) ...	No. 3. hot blast.....	17	2
Level, Staffordshire.....	No. 3. ditto	16	0
Mixed pig iron, five parts Low Moor, one part Elsecar	No. 3. cold blast	30	0
Mixed pig iron, five parts Bierley, one part Elsecar	No. 3. ditto	33	0
Mixed pig iron, No. 3, equal parts—Bierley, Elsecar, Low Moor, Staffordshire, (cylinder iron in the market,) Level iron, and Summerlee		20	2

These irons were all supplied in the regular way of business, without the makers knowing that such experiments were intended.

The fourth experiment was introduced in order to test the relative strength of wrought iron, made from cold and hot

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blast pig iron. The irons on which it had been tried were eight in number, the first set of bars were 2¼ in. in diameter, made with cold blast scraps, and hot blast respectively, all from Yorkshire manufacturers. The weight required to draw them asunder by a steady direct tension was not very variable, but when all were cut round to the same depth for the purpose of being broken with the hammer, they required about the following blows to do so.

Cold blast bar iron ..... six blows.
Scrap ditto ..... three blows.
Hot blast ditto..... one blow.

In the second and third set of bars, all of which were laid before the meeting held at Wakefield, the result of the experiments stood thus :—

	Diam. of bar. in.	Area of sec. where cut.	Blows required to break them with a 17 lbs. hammer.
Low Moor cold blast...	2.66	3.976	18
Bierley cold blast	2.76	4.430	18
Milton hot blast.....	2.75	4.430	3

			Blows required to break them with a 20 lbs. hammer.
Elsecar cold blast	2.58	3.976	21
Milton hot blast.....	2.58	4.202	1½

Made from the same materials.

So that the proportionate resistance of hot blast wrought iron to *impact* is still less than that of cast iron. With reference to the price of cold and hot blast iron, Mr. Hartop produced the following table,—

March, 1842.	per ton.
Price of Scotch hot blast iron at Hull, (No. 1,)	£3 7 6
To which add for its general inferiority to Yorkshire iron when both were made with cold blast	0 5 0
	3 12 6

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Price of Yorkshire cold blast iron at Hull, (No. 1.)	5 5 0
Difference in favour of cold blast iron in the market generally	1 12 6

He contended that it was a duty Societies like this owed to the public, to point out all such facts as were material to its interests, but more particularly such as bore directly upon its safety.

Further discussion took place between Mr. Morton, of Normanton, and Mr. Hartop; Mr. Morton holding, that, taking a commercial view of the question, hot blast was preferable, as it was cheaper. He contended that there were plenty of purposes to which the hot blast iron might be applied. He considered that no opinion could be formed upon the matter, as some of the most eminent and unbiased experimentalists had placed the iron of Bradford and its neighbourhood low down in the scale, a place which it had since been shown it ought not to occupy; and if doctors disagree who should decide?

Mr. HARTOP denied Mr. Morton's proposition, that there was any purpose to which hot blast iron could be applied in the quantity he had spoken of. There was no place in which it could be used with advantage over cold blast iron, considering that the saving in its manufacture was only 12s. 6d. per ton, as proved in his paper read at Wakefield in July; and the doctors having disagreed in this matter, the subject has been taken out of their hands by practical men, and hence the deteriorated value of hot blast iron in the market.

The discussion upon the matter, of which the above are the main arguments, continued for some time, but without eliciting any thing further.

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE TWENTY-FIRST QUARTERLY MEETING, HELD IN THE HALL OF THE LITERARY AND PHILOSOPHICAL SOCIETY, HALIFAX, ON WEDNESDAY, THE 8TH OF MARCH, 1843.

On the motion of Dr. Wm. Alexander,

John Waterhouse, Jun., Esq., F.R.S., F.G.S., was called to the Chair.

The Secretary proposed, and Dr. W. Alexander seconded, the election of John Waterhouse, Jun., Esq., of Halifax, and Mr. Edward Waterhouse, of Lindley, as Members of the Society.

The following Resolutions were then passed:—

1. That the thanks of the meeting be given to the Literary and Philosophical Society of Halifax, for their kindness in affording the use of their Hall on the present occasion.

Moved by Wm. West, Esq.;
Seconded by Henry Leah, Esq.

2. That the thanks of the Society be given to the Local Committee, for their attention in making the arrangements for this meeting.

Moved by B. Biram, Esq.;
Seconded by Thos. Pitt, Esq.

3. That the next meeting be held in Leeds.

Moved by the Rev. F. Russell, and
Seconded by Dr. Inglis.

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HENRY BRIGGS, Esq., of Overton, near Wakefield, then read the following paper :—

ON RENDERING AVAILABLE FOR AGRICULTURAL PURPOSES, A VARIETY OF MINERAL SUBSTANCES AND REFUSE FROM MINES, HITHERTO CONSIDERED OF NO VALUE.—BY HENRY BRIGGS, ESQ., OF OVERTON, NEAR WAKEFIELD.

The advantages to be gained by the employment of Chemistry in the service of Agriculture, are now so generally acknowledged, that I need not apologise for calling your attention to the subject. Surrounded as we are by elementary bodies, and their combinations, the properties of which are little known, it becomes a most important object to attain a more accurate knowledge of their effects, with a view to making the best use of them; and if we are aware that the elements essential to the growth and proper development of vegetables, lie hidden in the great masses of refuse from mines and other works, which are, *alone* and in *quantities*, most prejudicial to the husbandman, it must be an interesting inquiry, well worth patient investigation, to ascertain whether this refuse, by being employed in a proper manner and in moderate quantities, may not have a contrary effect, and confer a benefit instead of an injury. The well known fact that the most wholesome food when used *alone*, and for a continuance, is unable to sustain life; and also that a valuable medicine, improperly administered, or in too large a quantity, becomes a poison, will illustrate my meaning. This subject is so important, that I wish greater chemical knowledge than I possess had been applied to its investigation; but as I firmly believe no effort in the cause of truth, or for the advancement of knowledge, is lost or made in vain, I should think myself wrong in hesitating to lay before you a small amount of information, merely because it is not larger; and I will hope that some one who has greater power, may have as warm an

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inclination as I have, more fully to carry out this investigation. A recent indisposition having lately confined me in a great measure to the house, I have had leisure to make several experiments, the result of which I will proceed to detail. It is well known that in all animal and vegetable substances which are used as manure, the ammonia which is generated by their putrefaction is the most essential and valuable part, and is, at the same time, the most difficult to preserve. In fact, the farmer who, ignorant of this truth, endeavours to increase the value of the contents of his farm-yard by frequently turning it, retains a *body* without the *spirit*, and dissipates into the air the ammonia, which, as containing nitrogen, is so essential a constituent of his future crop. The ammonia generated by fermentation becomes almost immediately carbonate of ammonia, and in this state still remains extremely volatile; common smelling salts sufficiently attest this fact. It may, however, be imagined that ammonia so generated does not escape into the air to any considerable degree, but is retained in the body of the manure. I can, however, bring forward a circumstance that has come to my knowledge, which I think may fairly be adduced as a proof that the escape of this important fertilizer is greater than is generally supposed. In the neighbourhood of Wakefield there are some chemical works, where soda is prepared from common salt: during the process employed, the muriatic acid (one of the component parts of salt) is driven off into the air in the state of vapour, which, by the bye, is an extremely wasteful and deleterious proceeding. It was observed by the workmen that when the wind was in one particular quarter, and carried this vapour over a field where a large manure heap was deposited, a thick white cloud always hung over it. This cloud was caused by the escaping ammonia combining with the muriatic acid, and forming muriate of ammonia, or sal ammoniac, in finely divided particles.

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The celebrated Sprengel says, that "whoever fails to employ "some neutralizing substance to combine with the ammonia "which is produced in so great a degree during summer, "suffers a loss of manure which exceeds all belief. It is "only a gaseous substance, and not a solid material visible "to the naked eye, which thus escapes and is lost; but for "all that, it is of greater importance to the nourishment of "plants than perhaps any other portion of the manure." The still more celebrated Liebig says, that "the chief art of "agriculture depends upon the collection and *preservation* of "those manures which contain ammonia in the greatest quan- "tity." He also observes, in another part of his work, that "with every pound of ammonia which evaporates, a loss of "60lbs of corn is sustained." And many other writers of the present time, who have treated on the subject of manure, and its economical management, coincide in opinion with these eminent men, that the loss of ammonia deprives the manure of its most fertilizing property. How, then, can we arrest this valuable constituent, and prevent it from "wasting "its sweetness on the desert air?" Although we ought not certainly to consider it as entirely lost when it ascends into the atmosphere, as the next shower will again bring it down, yet to the farmer who wishes to apply his manure specifically, it is in a great measure wasted, as he has returned to him only a very small per centage of what has been derived from his own premises. Some months ago, in reading either Liebig's "Organic Chemistry," or Professor Johnstone's "Lectures on Agricultural Chemistry," (works which every one interested in agriculture ought to possess), I met with a suggestion that sulphuric acid might be applied with good effect to manure heaps for this desirable purpose; that is, of fixing, or rendering not volatile, the ammonia therein generated. The sulphuric acid, entering into combination with the ammonia, forms a neutral salt, the sulphate of ammonia, which is a

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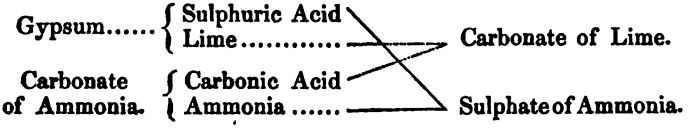
solid substance, soluble, and not volatile. I have lately used several cwts. of acid for this purpose, procured from my friend, Mr. Charles Norris, who manufactures it at his extensive chemical works at Sowerby Bridge. In order the better to distribute the acid, I caused it to be diluted with four or five times its weight of water, and periodically applied it to the manure; with what effect remains yet to be seen, although I can have no doubt of its beneficial result. The application of sulphuric acid being an expensive process, I afterwards adopted another suggestion derived from the same source, and used Gypsum or Sulphate of Lime to effect the purpose. Gypsum when burnt or baked, in order to drive off the water of crystallization, contains about 58 per cent of sulphuric acid; therefore in applying two tons of this substance, costing about £5, you, in effect, apply rather more than one ton of the acid, which from the chemist would cost about £11. This application of gypsum must depend, for its utility, on the correctness of the following theory, namely, that the sulphuric acid of the gypsum has a greater affinity for ammonia than for the lime with which it is combined, and that it will leave the lime and cling to the ammonia, forming sulphate of ammonia and carbonate of lime. The following diagram will exhibit this chemical process:—



To satisfy myself on this point, I mixed together, in a state of powder, a small quantity of gypsum and carbonate of ammonia, at the same time applying a little moisture, and a gentle heat. For two or three hours the volatility of the ammonia, evident from its pungent smell, continued still very perceptible; but in the course of a day it became less apparent, until at last all the peculiar pungency of smell ceased. To ascertain

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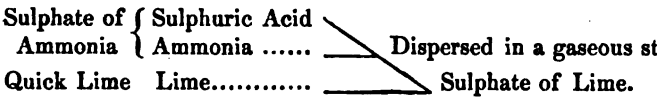
more satisfactorily that this volatility was subdued, I subjected the mixture to considerable heat. Had the ammonia continued volatile, this process must have driven it off; but afterwards, to prove that it still actually remained in the mixture, I added a little *quick* lime and moisture, upon which a re-combination took place; the sulphuric acid leaving the ammonia, and combining with the *quick* lime, and again forming sulphate of lime; the ammonia, in a gaseous state, flying off into the atmosphere. This latter part of the experiment I will show you, first premising, in order to reconcile this seeming paradox, that although sulphuric acid has a greater affinity for ammonia than carbonate of lime, as in the original or first experiment mentioned, it still prefers, and will combine with, *quick* or simple lime, and discards the ammonia to accomplish this purpose. This process is exemplified as follows:—



Here allow me to remark, that arguing from this result, it appears that the application of *quick* lime simultaneously with farm-yard manure, must be injurious; as the lime, when in the *quick* state, will tend to disperse the ammonia generated in the manure; but *carbonate* of lime, or lime become effete by long exposure to the atmospheric air, has not that hurtful tendency. The Rev. Wm. Thorp, one of the most active and efficient members of this society, and one to whom we have been indebted for many and valuable papers, in his Report, read before the Yorkshire Agricultural Society at Hull, on Agricultural Geology, seems to doubt the assertions of Liebig, Dr. Daubeny, Professor Johnstone, and others, "that the use of gypsum is "to fix or to deprive ammonia of its volatility, that a double "decomposition takes place, and that sulphate of ammonia "and carbonate of lime are formed." I think that what I

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have stated above, and the experiments tried, are sufficient testimony to the correctness of the theory of those eminent gentlemen, and prove that the double decomposition does actually take place. Having satisfied myself that great benefit might be derived from the application of gypsum, it struck me that it was possible to find the same properties, though in an inferior degree, in some of the unsightly masses of refuse surrounding coal mines. I therefore proceeded to examine the following substances, namely, common coal ashes, burnt slack or refuse small coal, mixed with drosses or iron pyrites, burnt blue metal or indurated clay, found in sinking pits, and frequently forming the roof and floor to coal, in which are often embedded fossil shells and vegetable remains, the whole turning to a red colour when burnt; and other strata which burn to a white substance. I have also examined a strongly impregnated mineral water, which exudes during wet weather from the coal when stacked on the surface. Had my chemical knowledge been greater, I should more accurately have analyzed them; as it is, I have only been able to detect some of their ingredients, without minutely ascertaining their precise qualities. But I believe I can prove, nevertheless, that they do contain many substances, which, under proper treatment, may be rendered available. Of these the chief is sulphuric acid, the presence of which I have detected in all; and, as is the case in gypsum, this is valuable by arresting ammonia when brought into contact with it. Before we can, however, with safety apply these refuse substances to heaps of manure, we must endeavour to ascertain the nature of the other ingredients, lest they should prove prejudicial. I think I can show you that they contain both lime and iron; in fact the circumstance of the refuse burning to a red colour is sufficient proof of the presence of the latter; and the former (lime) may be accounted for from the frequent recurrence of fossil shells, which are composed of lime;—[a specimen

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was here exhibited to the meeting]. The first of these substances (lime) is almost universally acknowledged to be beneficial, and the second (iron) when in the state of a Peroxide, is likewise stated to be so, when present in the soil in small quantities. On referring to the analysis of fertile soils, made by Sir Humphry Davy, Liebig, and Sprengel, I observe that there is invariably present a portion of oxide of iron, varying from two to eight per cent.; and I find from a table of the fixed constituents of various crops, issued by the latter chemist, (Sprengel), that the same substance is always detected in a greater or less degree, proving it to be essential to the proper development of the plant. From the examination to which I have subjected these different kinds of refuse, I believe them to contain also alumina and magnesia, both of which are constituents of fertile soils, and their vegetable products. In fact we have lately had a decided proof of the presence of magnesia in burnt refuse. We were leading upon the land a heap of slack and pyrites which had long been in a state of ignition, and found on removing it, a thick layer of crystalized salt, which, on examination by a professed chemist, was pronounced to be simple sulphate of magnesia or Epsom salts; [a specimen was here exhibited]. The burnt refuse of a pit hill has been successfully employed by Mr. Forge, steward to Sir Wm. Pilkington, at Chevet Hall, near Wakefield, as a substitute for riddled ashes from houses, mixed with bones, for his turnip crop. He informed me that the portion of land on which this refuse was applied, bore a decidedly better crop than the part where the common ashes were laid. It should likewise be considered that ashes and burnt mining refuse will have a mechanical effect upon a stiff soil, after the chemical action ceases, and will improve its texture by rendering it more porous and easier to be worked by the plough and harrow. The prevailing character

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of the land in England is of this nature, especially in the coal districts. A stiff soil is much more capable of permanent improvement by assiduous cultivation than a light one, and it is to land of this nature that we must look for the increased production which is necessary for the prosperity of the agriculturist.

Engine ashes are frequently considered as a nuisance, but, when riddled, the smaller part may be usefully employed as a top dressing to heavy stiff land, while the larger portion acts well as a filling for drains. In two instances (one of them in consequence of my own recommendation) I know them to have thoroughly answered for the latter purpose, and the drains are very effective. The larger portion of the burnt coal-pit refuse would no doubt answer equally well. On the table is some of the mineral water before alluded to, which is remarkable for the quantity of sulphuric acid which it contains, partly combined with iron: the presence of both can easily be manifested—the iron, by applying ferro-prussiate of potash, and the sulphuric acid with nitrate of baryta. From the quantity of acid which is perceptible, part of which is free or uncombined, I conceive it may be used as a substitute for the sulphuric acid of the manufacturer, or for gypsum, in fixing ammonia, and I have so applied it. May it not also be used beneficially in the slacking of lime, by which gypsum would be formed? Sir Humphry Davy, in his lectures, says:—"I have witnessed the fertilizing effects "of a ferruginous water used for irrigating a grass meadow, "near Woburn: I have no doubt the vitriolic water acted "chiefly by producing gypsum." Wherever coal is much impregnated with sulphuret of iron or pyrites, on exposure to the weather, the water draining from it will be, more or less, found of a similar quality. [A Salt, obtained by the evaporation of this water, was on the table.]

At a colliery, there are generally large accumulations of

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very small coal-dust, which is the refuse after what is called riddled slack is extracted. It is again an interesting inquiry —Can this be made useful in the raw or unburnt state? for, being so small, and lying so close, it refuses to be consumed by itself. Pure coal is composed of oxygen, hydrogen, nitrogen, and carbon, in different proportions, according to the nature of the coal: none of these constituents are in themselves injurious to vegetation, and, if there be any thing deleterious in the application of coal to land, it appears to me that it must arise from the extraneous matter there found; the bad effects of which may, I conceive, not only be neutralized by the addition of lime, or other correctives, but may, very probably, be rendered actually fertilizing. This experiment I am now trying, having made a compost heap of one-fourth lime and three-fourths coal-dust, which is applied both to wheat and grass land, the result of which cannot be properly appreciated until the crops arrive nearer to maturity, but at present the wheat looks promising. As evidence that lime does at any rate neutralize any bad effects arising from an excess of small coal being scattered over the surface of land, I beg to refer to a letter in the *Quarterly Journal of Agriculture*, dated September, 1828. The writer says:—

"A farm which I occupy has been completely undermined "in working for coal. As the seam is near the surface, "great injury has been occasioned by the small coal remain- "ing upon the surface, and getting mixed with the soil. "The numerous places where either the coal or water "has been raised, were either quite barren, or, if sown "with corn, though it frequently vegetated, yet it always "became unhealthy, and shrivelled up before the harvest. "I tried removing and mixing it up with the soil, or entirely "covering it over. These methods were only partially suc- "cessful, and could only be accomplished at a considerable "expense. I had somewhere heard that lime, if applied in

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" a considerable quantity, would destroy any acid in the coal. " I first tried it upon some patches in a fallow field, which " were sown with Wheat in 1826, and I thought I had been " successful; but though the plants looked healthy during " the winter and the spring, yet, towards the harvest, they " became shrivelled, and were not very productive. I re- " peated the experiment the following year, again upon fal- " low, but applying nearly double the quantity of lime; and " have been this year so fortunate as to reap as much wheat " as from the other parts of the field, and the grass seeds " look better than on the adjoining parts. The patch was " very irregular, yet I may venture to estimate the quantity " of lime at about twenty cart loads per English acre, from " the kilns; but I am convinced that I could scarcely apply " too much, particularly as the coal is known to contain a " great quantity of sulphur, which, becoming acidified by " the action of heat and air, produces sulphuric and sul- " phurous acid, the very poisonous effects of which are ably " pointed out in your paper. I mean to follow up this " experiment, and hope to be able to convert to fertility " those barren places which are so very annoying to the eye " of the farmer, when they appear at harvest in fields other- " wise covered with corn."

Here, no doubt, there was an excess of acid, as the writer conjectures, and the lime would have a chemical effect in neutralizing that acid and forming sulphate of lime or gypsum, which is a valuable assistant in agriculture; and thus the very property of the coal, which was considered poisonous, was converted into nutriment. We have ourselves experienced the good effects of applying to land the small coke which is produced by riddling that which we supply to the railway; as our most promising crop of wheat is on a field which was profusely dressed with that refuse.

There are many other substances, hitherto considered of

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little or no value, which might, no doubt, be rendered available for the amelioration of land, amongst which I will merely mention two or three, which, when they can be readily obtained, ought not to be neglected by the farmer. I allude particularly to the scrapings from roads repaired with the foundry dross, and those repaired with lime-stone. The former is said to contain silica, lime, and potash, which are essentials in securing a good crop of corn, and the latter is carbonate of lime, the beneficial effects of which I believe few will dispute, at least on land where there is not already an excess of calcareous matter. Other road scrapings might also be advantageously applied to *stiff* land from their *mechanical* action, though their chemical properties might not be very appreciable.

After I had made the above detailed experiments, I accidentally met with a paragraph in the *Farmers' Magazine* for January last, which has strengthened and confirmed the ideas that I had previously entertained of the available nature of mining refuse. It states—

" Count Hompesch, a Belgian gentleman, has taken out a " patent for the preparation of a manure more powerful and " cheaper than any yet invented. His plan is said to consist " in fixing all the volatile parts of nightsoil and other such " substances, by means of the ashes of the oölitic shale of " Portland. The shale is employed, in the first place, as a " source from which oil, turpentine, and other substances are " extracted; the residue goes to the preparation of the " manure, which is said to be converted somewhere on the " Isle of Dogs, and sold in a dry state in the form of bricks. " As the materials to be thus employed are inexhaustible, " and at present almost valueless, it is expected that the pre- " paration of the fertilizer in question will become a matter " of great national importance. As people have become too " wise to wonder at sugar being made from old rags, so will

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" they be equally prepared to hear that oil, and tallow, and " soap, are to be fabricated from the hardened mud of the " coal mines—for such is shale."

In Cornwall, also, I believe, the mining refuse is exciting attention, and I understand that a weak description of sulphuric acid is obtained from it by distillation, which again is used in the process of manufacturing common soda.

It has frequently occurred to me as an extremely interesting speculation, whether, as Chemical science advances, a method may not be discovered of cheaply producing ammonia from its constituents, hydrogen and nitrogen, obtained from water and air,—the chemical combination being accomplished by the agency of Galvanism, or some other powerful means.

Having now given you the result of experiments very interesting to myself, and which I hope will lead others to a continued investigation of a subject that may ultimately be productive of great advantage, allow me to call the attention of those interested in Agricultural Chemistry to an analytical table of the constituents of various cultivated plants, originally drawn up by those eminent chemists, Boussingault and Sprengel, and which I have caused to be re-printed, with some modifications and additions, from one furnished to me by Mr. Haywood, analytic chemist, of Worksop. This table clearly points out to the farmer the fixed constituents of any given vegetable produce; and the plain inference is, that unless his crop can obtain those constituents from the soil, he must not expect a perfectly developed plant, or, in other words, he must look in vain for a good crop. If his land is deficient in any of those constituents, they must be introduced artificially. Under this system, I think it not too much to expect that, with proper scientific management, even successive good crops of wheat may be raised on the same land, by supplying

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to the soil those constituents which, as analysis points out to the inquiring mind, become exhausted by such treatment. Could this table be used in conjunction with an analysis of the soils on which his efforts are to be employed, the agriculturist might indeed feel that science had opened to him a prospect of almost boundless improvement in the results of his labour; and it could no longer be said that "Agriculture "owed nothing to Chemistry."

At the Evening Sitting, the following Paper was read:—

ON THE RECIPROCAL PROPELLING POWERS OF FLUIDS, AND CERTAIN ROTARY MACHINES UPON EACH OTHER. BY B. BIRAM, ESQ., WENTWORTH.

The object of this communication is to elucidate the principle of action and proper construction of those rotary machines which derive their motion from the oblique impulse of fluids, as in the vertical windmill; or which, on the other hand, are capable of giving motion to fluids by an oblique impulse; being themselves propelled by some other source of power.

Since the introduction of steam power, wind, as a prime mover of machinery, has been comparatively little thought of; yet, from the abundant supply which often sweeps over the land, and from the great economy of its application, it is well deserving of consideration. We find, however, that little has been done for a long series of years towards the improvement of this description of power; that nearly the same form of windmill sail is still adhered to which the illustrious Smeaton found to be the best; and that the employment of wind for driving machinery, instead of progressing,

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is, on account of its uncertainty, and from the difficulty occasionally of governing its impetuosity, fast sinking into disuse. Being fully persuaded that this power deserves more the attention of scientific men, after considerable thought upon the subject, and at the risk of being thought presumptuous, I have ventured to question the truth of the conclusion at which Smeaton arrived after his numerous experiments, and now submit, that the shape of sail which he recommends is capable of improvement, and that with properly constructed sails, the whole cylinder of wind in which they may be said to revolve, may be advantageously intercepted, whereby the same area of resisting surface may be presented to the wind, with a reduction of 2-5ths of the diameter of the sail, or, retaining the same diameter of the sails, the power of the mill may be nearly doubled.

I think it will be evident to all who pay attention to the subject, that every portion of the sail should present a proportionate resistance to the wind, and should recede from its impulse with that velocity which would least interrupt the wind's onward progress. If the object in view were to produce rectilineal motion, such, for instance, as the propelling a carriage upon a railway in a right line oblique to the wind's direction, the best form of sail would doubtless be a flat surface, and the angle with the wind uniform throughout: but the circumstances are much altered when a rotary motion is required; in that case the velocity of the sail varies constantly from the extremity to the axle, whilst the wind continues to act upon the sail with equal velocity throughout the whole area of the revolving circle. In order, therefore, that the sail should present a due resistance to the wind, and on the other hand not disadvantageously intercept its progress, that form should be adopted which is the best calculated for securing this object.

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The sail of a windmill will, of course, be the length of the radius of a circle in which it revolves. *The parallelogram* A B C D, *Fig.* 2, *represents this radius;* C B *being the axle, and the length being divided into six equal parts.* Let AB, *Fig.* 1, equal the curved line

FIG. 1.

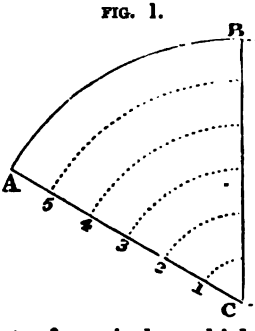
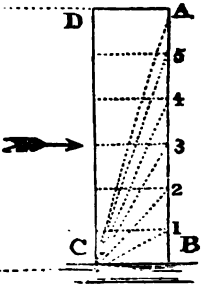


FIG. 2.



of the sixth part of a circle, which the periphery of the revolving sail would describe, the chord of its arc would then be equal to the radius A B, *Fig.* 2, and the chord of the several arcs 5-5, 4-4, 3-3, 2-2, 1-1, *Fig.* 1, would be respectively equal to the lengths 5B, 4B, 3B, 2B, and 1B, *Fig.* 2. The periphery of the sail A B, *Fig.* 1, being placed at an angle with regard to the plane of rotation, the two points would not revolve in the same line, but would describe a cylinder, the depth of which may be said to be D A, *Fig.* 2; and as the length of the lines A B, *Fig.* 1 *and* 2, are respectively equal to each other, the angle C A B, *Fig.* 2, would be the angle of the extremity of the sail with the plane of rotation. The sail being considered without friction, the tendency of the wind on the oblique plane A B, *Fig.* 1, (represented by A C, *Fig.* 2, the arrow denoting the direction of the wind,) would be to cause the sail to revolve from A to B in the time the wind passed from D to A, and as the several other portions of the sail would in the same time each pass through the spaces 5-5, 4-4, 3-3, 2-2, 1-1, the angle which the sail should present at those several points, should be respectively C 5 B, C 4 B, C 3 B, C 2 B, and C 1 B.

The form of sail which Smeaton recommends accords in some measure to this principle, inasmuch as the angle of

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the sail with the plane of rotation increases towards the axis; but it is not clear that he has any rule for determining those angles, more than that they were the angles of those sails with which he experimented, which produced the greatest mechanical effect. The following are the angles which he prescribes:—

SMEATON'S CONSTRUCTION.

Radius divided into 6 equal parts, *(see Fig. 2)*	1	2	Middle. 3	4	5	Extremity 6
Angle of the sail with the axis ...	72	71	72	74	77½	83
Angle of weather ...	18	19	18	16	12½	7

CONSTRUCTION HEREBY RECOMMENDED.

Weather angle, supposing the extremity 7° ...	37	20½	14	10½	8½	7
Ditto, supposing the middle 18° ...	43	26½	18	13½	11	9

With sails formed upon Smeaton's plan, I am not surprised that he found the whole cylinder of wind could not be advantageously intercepted; but with properly constructed sails, I am persuaded that he would have arrived at a different conclusion, and that he would also have found, that the angle at which the extremity of the sail might be advantageously set, would admit of a much more extensive range, where the products of the velocity, multiplied by the weight raised in a given time, would have produced an uniform maximum result. At least, so I have inferred from the following experiments.

It is not easy to show the unnecessary obstruction, and consequent loss of power, which the wind encounters from ill-formed sails; but if water be the medium in which the sails are made to revolve, very conclusive evidence of the fact may be exhibited. If in any vessel of water a number of small pieces of paper, bran, or other light body of about the same specific gravity as water be sprinkled, the effect

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produced upon the floating bodies by sails at different angles and of different constructions, will be seen by submerging the sails, and passing them through the water in the direction of the axis. If the sails be formed of the construction hereby recommended, they will revolve without materially disturbing the particles of floating matter; but in proportion as the form differs from this principle, there will be more or less disturbance of the water, and commotion amongst the bodies floating therein.

These experiments in water also clearly establish the law which governs the velocity of revolving bodies, acted upon by fluids on this principle. For let A B, *Fig.* 3,* represent the plane in which the wheel rotates upon its axis, and the oblique lines drawn from B, and terminating in the line A C, be the angles which the extremity of the vanes of variously formed wheels make with the plane of rotation; then supposing A B also to represent a line of the same length as the circumference of the wheel W, *Fig.* 4, and the angle A B E be that which the extremity of the vane or sail forms with the plane of rotation, the wheel upon being moved through the water in the direction of the axis, would make one revolution in the distance A E, or *four* in that of its own circumference. If

FIG. 3.

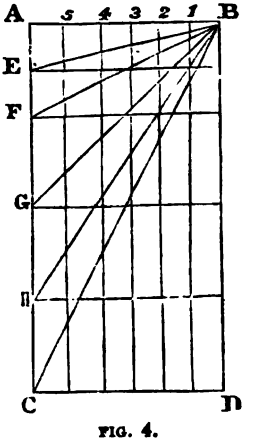

FIG. 4.

* This diagram, *Fig.* 3, presents a convenient method of ascertaining the proper angles to be given to vanes or floats at any required distance from the centre of the wheel, the angle at any one distance being given.

The line A B represents the radius of the wheel, B D the axis, and A C the periphery of the wheel, the lines 1, 2, 3, 4, 5, divide the radius into six equal parts. The angle which the vane is to have at any given distance from the centre of the wheel, must be set off from the point B, on the line B C, through which an oblique line should be drawn until it intersects the vertical line at the

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the angle of the extremity were A B F, it would make one revolution in the distance A F, or *two* in that of its own circumference, and so on; if the other oblique lines represented the angle of the extremity of the vane of the wheel, the wheel would revolve once in the distance from A, to where its corresponding oblique line intersected the line A C. I have proved these to be facts by a variety of experiments. In the first instance, I procured three tin models ten inches diameter and two-and-a-half inches deep, which had each six vanes, but at different angles, from which I found that a revolution was made by each wheel upon being passed through the water, in distances proportionate to the tangent of the angles, as already described. From this I inferred that the principle would prove a correct one for measuring the velocity of currents of water, or of vessels through the water; I had, therefore, two wheels constructed, the circumference of each of which was the 1000th part of a mile: the vanes of one were made with the periphery at an angle of 45°, or A B G *Fig.* 3, and the other at an angle of 26° 34′, or A B F, the intention being that the first should make 1,000, and the latter 2,000 revolutions in a mile. Wheel work was attached to each, so arranged as to cause an index to make one revolution round a dial plate fixed a little above each of the wheels in one mile, which dial plates were subdivided to mark furlongs and chains. To test these wheels I measured the distance of half-a-mile on the straight bank of a canal, leaving a mark at each furlong; and, afterwards getting into a boat, I was hauled along the canal parallel to the measured distance, each wheel being successively submerged through that distance; when the distance recorded by the index of each wheel was

given distance; through this point of intersection draw a radius line parallel to A B, and oblique lines drawn from B, to the several points of intersection of the vertical lines thus found, will be the angle which the vane should make at those several distances from the centre line B D.

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found minutely to coincide with the distance previously measured upon the bank.*

From these experiments I am persuaded that this construction of wheel is well adapted either for registering continuously the progress of a vessel through the pathless deep, or for ascertaining at intervals, as a substitute for the common log, what is the rate of sailing at the time of observation. For the latter purpose a small wheel one foot in diameter would be sufficient, attached to the side of the vessel, so contrived as to be let into the water or withdrawn at pleasure. The motion of the wheel might readily be transmitted by a rod, working in a tube to an index near the observer upon deck.

But the very powerful tendency which these wheels possess of rotating upon their axes when placed in a stream of water, show that they admit of very extended application. Not only will they be found an improvement upon the common windmill sail where a defect in construction, in consequence of the elastic nature of the moving power, cannot be easily detected, but they may be advantageously substituted for the undershot water-wheel, in rivers and situations where there is greater depth of water than can be made to act upon the floats of such wheels. The undershot water-wheel can only be advantageously immersed in the stream to the depth of a certain proportion of its radius; to increase, therefore, its power, its bulk must be increased in an extraordinary degree. These wheels, on the contrary, admit of any depth of immer-

* I have since made others of a very delicate construction, and have found them calculated to measure with tolerable accuracy the velocity of the wind or the currents of air through mines; to these I have attached wheel-work to register the current which had passed through them up to 1,000,000 feet. I had also contrived an apparatus to be attached thereto, so that not only the velocity of the air at the time of observation could be registered, but the machine itself would register what *had* been the velocity at any period during the interval of a week. In this apparatus, however, I have reason to suppose, I have been anticipated by a gentleman who has recently taken out a patent for a similar invention.

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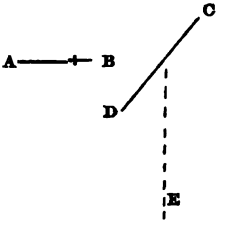
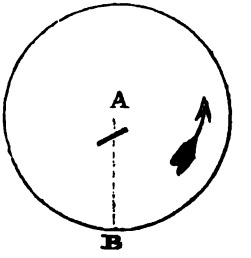
sion, and their power would increase in proportion to the area of their immersed surface. A powerful undershot wheel requires not only to be of large diameter, but also of great breadth, to give sufficient area to the acting floats. These, on the contrary, may be made exceedingly narrow, and there would be no advantage in their breadth exceeding one-eighth of their diameter.

These are among the useful applications of such formed wheels, when impelled by fluids. We have now to consider them as applied to give motion to fluids when impelled by some other source of power; and as in the first instance the rotation of the wheel upon its axis was the quickest when the angle of the vanes with the plane of rotation was the smallest, so I have found that the motion of the propelled fluid is greater in proportion as the angle of the vane with the plane of rotation is greater, within certain limits. For if the wind acting in the direction A B against the body C D, placed obliquely to its course, would impel the body towards E, so I conceive will the body C D, striking the air in the direction A B, have an equal tendency to impel it towards E. This may be illustrated by a circular vessel filled with water, in which draw any flat body held as in the position A frequently towards B, and the water will soon assume a rotary motion in the direction of the arrow, more or less quick as the plane of the body makes a greater or less angle to the dotted line A B.





This appears to me nothing more or less than the action of sculling, by which the oblique action of the oar causes a quantity of water to recede from the stern of the boat,

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whilst the oar, re-acting upon the boat, causes it to advance with the difference between the resisting area of the oar and boat. All the sub-aqueous stern propellers—the Archimedian screw, as it is called, Blaxland's, and others—may also be called rotary sculls, more or less perfect in principle, the great defect of most of them being, that the angle of the blade with the plane of rotation is too small, thereby requiring, to produce the required speed in the vessel, far more revolutions in the propeller than the strokes of the engine; which is accomplished by additional drums and straps, or cog-wheels, by so much increasing the friction, and consequent wear and tear of the machinery.

By the aid of the tin models already referred to, I made the following experiments:—I procured two tin boats about two feet long, which were coupled together, leaving sufficient space between for the propellers to revolve when placed at right angles to the path of the boats. The power applied to put them in motion was a clock spring, whereby each wheel made forty-two revolutions whilst the spring was unwinding. The vanes of the first wheel were at an angle of about 25°, which propelled the boats, by forty-two revolutions of the wheel, 54 links in 35″. The angle of the second was 45°, by which, in the same number of revolutions of the wheel, the boats were propelled 120 links in 1′ 15″. By the third, with vanes at an angle of 53°, the boats were propelled 150 links in 1′ 43″. These several distances coincide with what I have advanced, the distances being in proportion to the tangents of the angles of the vanes; they show that when the angle of the propeller with the plane of rotation is increased, the resistance to rotation is also increased; yet that there is no loss of power, but that by so much as the propeller more slowly rotates on its own axis, the boat is by so much more advanced with one revolution of the propeller.

By other experiments I also found that there is a certain

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ratio of breadth to the diameter of the propeller, from which a maximum result will be found. I tried a propeller having eight arms, the angles of which were at 56°, and the proportion of the breadth to the diameter about $\frac{1}{8}$th, which answered remarkably well. I thought that probably another with four arms at the same angle, and of the same length, but double the breadth, would answer as well; but I found that the speed of the boat was thereby greatly diminished, and the distance performed not so great. I have also found that there is a decided loss by too many arms in the propellers: the third propeller mentioned in the last paragraph, having six arms, propelled the boats 150 links in 1′ 43″; another of the same diameter and angle, having sixteen arms, required 2′ 10″ to accomplish the same distance. From this it would appear that in addition to the particles of water which are put in motion by the actual contact of the propeller, there is an extra quantity moved by the attraction or cohesion of the particles of water to each other, and that therefore the distance of the propellers from each other should be such as to take full advantage of this principle; and that if they be too much crowded in the wheel, they prevent the proper escape of the water, and tend to retard the velocity of the vessel.

The success attending these experiments in propelling upon water, induced me to turn my attention to the same principle to propel air. I have now in my possession a model which clearly illustrates the great capability of a wheel of this construction. The model is twelve inches in diameter and two inches broad; it has eight vanes, the periphery being at an angle of 45 degrees; it is mounted upon a frame at one end of a covered opening, a little exceeding the diameter of the wheel, and about eighteen inches long, and is put into motion by a wheel and pinion, by which a great velocity can be given to it. In the other end of the opening, I fix one of the wheels I have made for measuring the velocity of currents

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of air, and by turning the wheel one way or the other, I can readily cause a current of air to pass through the passage, in either direction, at the rate of 900 to 1,000 feet per minute. I think there cannot be a doubt of its great applicability for ventilation of public buildings, the holds of ships, and also for mines. The construction is simple and economical, the space which it would require would be small, and the current of air which it would propel would far exceed in quantity that of any other wheel of the same dimensions.

Martyn J. Roberts, Esq., F.R.S.E., then read the following paper,—

DESCRIBING THE PROCESS OF BLASTING BY MEANS OF GALVANISM.

It is only within a short period that the science of electricity has in any manner been applied to the arts, but it offers to our use a powerful agent that will soon be directed in a thousand ways to the improvement of our chemical processes and manufactures. We have already its assistance in the rapid transmission of intelligence by the galvanic telegraph—in the multiplication of engraved plates—in the art of gilding and silvering metals—in assaying ores—and lastly, in that I now bring under your notice, the firing of gunpowder in blasting rocks, either in quarries, mines, or subaqueous operations. This application of the electric fluid was carried into effect by me, long before the discoveries I have mentioned, for it is now many years since I attempted to introduce it into the mining district of Cornwall, and it is right that it should have your first and most earnest attention, it being mainly directed to the saving of life, and preservation from injury, to the poor labourer, who, by the use of the old process of blasting, was too often unhappily deprived either of life,

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sight, or limb. Such being the object for which I first contrived an apparatus for this employment of electricity, I am sure you will join me with equal ardour in spreading a knowledge of the process, and in inducing workmen and masters to use this safe and powerful agent in their daily operations in mines and quarries. Were this object too feeble an incentive, (which I would not for a moment believe it to be in this Christian and charitable country,) I might perhaps arouse masters to a sense of its importance, by showing them how great would be their gain in a pecuniary point of view, for it can be proved that at least one-half the gunpowder necessary in the old process would be saved by the adoption of this new method; indeed, a correspondent in the *Mechanics' Magazine*, who states himself to be connected either as lessee or proprietor of slate mines in North Wales, says, that he finds one pound of gunpowder as effective, by the use of the several precautions I have pointed out, as ten pounds, if used on the old plan of blasting rocks. To explain more easily in what manner the freedom from danger is obtained, it will be well that I first describe the old method of blasting, together with the dangers attendant on it, especially as there may be many now present not conversant with the operation. When a rock is to be riven or torn from its bed by gunpowder, a hole is bored in the necessary position, about two inches in diameter, and varying from two to twenty feet in depth; when dry and clean, the charge of powder is poured into it, and in order that the force of the explosion may as much as possible be expended upon the rock, the charge is confined in this hole by filling it with loose stones or gravel, (technically called tamping or stemming) from the gunpowder to the surface of the rock, with this exception, that a small aperture or channel is allowed to remain through the tamping stuff, for the purpose of firing the charge of powder, by a match or train, from

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the surface of the ground; in fact, a touch hole, only much longer and wider than is to be found in muskets or cannon; through this vent or touch hole the charge is fired, generally by a long straw filled with powder, or sometimes by a rope fuse, ignited by a workman on the rock. The danger attendant on the whole of this process is very great; in the first place, the hole must be filled with loose stones or gravel, which must be rammed down with great force by means of a metal ramrod; it not unfrequently happens that a spark of fire is elicited by the collision of the ramrod with the sides of the hole, or with the stones of the tamping stuff: this spark falls upon the powder and causes an explosion, maiming or destroying all the poor workmen in its vicinity. Again, supposing this process to have been safely performed, the workman sets fire to the train, but, if this should burn too rapidly, he has no time to escape before the explosion takes place, and he is surely injured by the flying fragments of rock. But a source of accident even more common than this is the hanging fire of the train or fuse; when this happens, the workmen, fancying it extinguished, return to the rock for the purpose of remedying the fault, when, perhaps, on their arrival there the fire reaches the charge, and, exploding, destroys all within reach. These are some of the dangers attendant on the old process of blasting—one which, I believe, daily causes the death or serious mutilation of the workman in some part of this kingdom.

The pecuniary loss attendant on the old method is very great, but arising from several defects which are completely remedied by the use of electricity and the other improvements I have had the good fortune to introduce, and some of these defects I will point out. In the first place, the touch or vent hole, which must necessarily be maintained in the tamping stuff, is a channel through which a great portion of the exploded charge expends itself, and is therefore wasted.

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Now, all chance of loss in this manner is avoided by the use of electricity in firing the powder, because the fluid passes through a solid wire to the charge, and no aperture whatever being left in the tamping stuff, the consequence is, that the whole force of the explosion is expended upon the rock; it has no other mode of escape, except by blowing out the tamping stuff altogether, an accident which can be avoided by the adoption of another improvement, which I will presently explain; but if the old mode of tamping is used, this blowing out of the stuff is of frequent occurrence, because the workmen, knowing the operation to be one of danger, hurry it over and perform it inefficiently. The dangers I have described are avoided by the use of galvanism in firing the charge, because the apparatus is so contrived that it is impossible the powder can be ignited before the workmen expect, and they have time to secure themselves ere the explosion takes place. Should any accident occur to prevent the charge from going off, the battery can be thrown out of action by pulling a cord, and then there is no danger in approaching the rock, for electricity never hangs fire.

It is now five years since I introduced blasting by galvanism into the mining districts of Cornwall, but the apparatus I then used was imperfect, as I had much to learn by observation and experiment. I subsequently made further improvements in the machine, and employed it with great success in Scotland, both in quarries and under water. After this General, then Colonel, Pasley found the same process very efficient in his operations against the Royal George, at Portsmouth. It then came into frequent use in all parts of the country, and I have now further increased its practical simplicity, as will be shown to you this evening.

Electricity, when generated by means of the contact of metallic plates and a liquid, is, for the sake of convenient

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distinction, called galvanism, and it is electricity in this form that is employed in blasting. If we connect a copper and a zinc plate together, by a metallic wire, and immerse them in dilute acid, a violent effervescence will be seen; this is caused by the action of the acid upon the zinc, which action generates a current of electricity flowing from the copper plate through the wire to the zinc, and it is with this current we work, whether it be to decompose water, gild metals, or what is now more to our purpose, to generate such an intense heat in the conducting wire as will ignite gunpowder. Such are the elements of an apparatus for blasting, and even this simple battery would be sufficient could we place it within a few inches of the rock to be rent; but as safety requires that it should be some distance off, and as a contrivance must be used to enable the workman to throw the apparatus into action, and also to arrest the current of electricity at the required moment, some complication in its construction will be necessary: thus, to allow of the requisite distance between the machine and the rock, we must give the current of electric fluid a sufficient power to overcome the resistance a long wire would offer to its progress.

Electricity may be said to exist in two conditions, viz., *intensity* and *quantity*. *Intensity* I have defined as that quality which tends to overcome obstacles to its progress; *quantity*, its power to act upon those obstacles: for example, if we wish to pass a current through a wire of considerable length, there must be sufficient *intensity* in that current to overcome the resistance offered to its transit through the wire; for although metals are excellent conductors of electricity, yet the best of them oppose its transmission to a considerable degree, and, in order to heat any part of this wire, there must be a *quantity* of electricity passing proportionate to the thickness of the wire. In a galvanic battery we gain quantity of electricity by increasing *the size* of the

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metallic plates, or the strength of the exciting liquid; to obtain intensity, we must increase the *number* of the plates, and join them together in series or sequence; thus the first zinc is joined to the second copper plate, the second zinc to the third copper, and so on, until we multiply the pairs sufficiently to obtain the desired intensity.

The first kind of battery I used, was such a series of copper and zinc plates, excited by a solution of sulphate of copper, (which has been fully explained in my pamphlet on the subject,) but this arrangement was afterwards improved by substituting iron for the copper plates, as I discovered that iron was superior to copper if the battery was to be in action for some time; the cause of this phenomena, which at first sight appeared at variance with our received notions of electrical science, will be found fully explained by me in the *Philosophical Magazine* for June, 1841. This iron battery was filled up without the intervening cells that are commonly employed, such an arrangement being cheap and easy of management, but it had the defect of diminishing the intensity of the electric current, and was therefore not very applicable to situations where it was necessary that the battery should be far removed from the rock.

Since this I have contrived a battery, which is now brought, for the first time, before the scientific world; and that now shown to you has been made expressly for this Society. There is no doubt that for the purpose of firing gunpowder and other such momentary actions, it will be found far more powerful than any hitherto made, simply because we avail ourselves of the intense current of electricity always developed at the first instant of the immersion of the plates into the exciting solution. This battery consists of twelve copper cylinders 2¼ inches in diameter, and 10 inches long, closed at both ends; a cylinder of zinc is fixed into each of these copper tubes, and being only 6 inches long, extends from the

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bottom to a little beyond half the length of the copper cylinders, care being taken to prevent the zinc from touching the copper tube in which it is inclosed: they are kept separate by small bits of cork. Each copper tube and its enclosed zinc forms a galvanic pair, and these are joined by wires in sequence or series as before described, viz., the first zinc to the second copper, the second zinc to the third copper, and so on to the end of the series, excepting the last zinc, which has no metallic connexion with any copper tube, its wire projects for the purpose of attachment to the main wire or conductor conveying the electricity to the rock; the first copper tube is in like manner unconnected with any zinc, and has a similar projecting wire for attachment to the main conductor. These terminal tubes or their wires are called *poles;* that of copper is the positive, and that attached to the zinc the negative pole.

All these cylinders, insulated from each other, are placed in a frame suspended by an excentral axis, somewhat in the same way that a mirror is hung on its frame, the cylinders contain sulphuric acid and water, in the proportion of one part acid to sixteen of water, and when the battery is not in action, the ends of the copper tubes containing the zincs are uppermost; the consequence is that the exciting solution falls to the bottom of the copper tube, and is thus removed from contact with the zinc, but when a current of electricity is wanted, the frame can be reversed by pulling a string, the dilute acid falls upon the zinc tubes, and the battery is thus set in action; to stop the current of electricity, the frame is turned into its original position, and the zinc tubes removed from the exciting solution. By this contrivance we obtain the full effect of the first immersion of the plates in dilute acid, which, it is well known to electricians, is in a manifold degree greater than any effect that can afterwards be obtained; so much is gained by this, that for ordinary purposes of

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blasting, a battery on this construction, not much larger than a quarto volume, would answer well enough: but the one now shown to you is of a very large size, and sufficient for the most extensive operations. Its construction renders it of easy management to the workman, as he has only to place it on the ground twenty or thirty feet from the rock, and pull the string, when the explosion is wanted. The master miner or quarryman will occasionally replenish the battery with acid; but as it is in action for so short a time at every discharge, this need hardly be done above once in the month, and a shilling's worth of acid would last ten or twelve months, even were the apparatus in daily or hourly use.

It would trespass too much upon your time were I to enter into more minute details of the construction of the battery, but if persons desire it more fully explained to them, I shall be happy to do so at any time; and indeed it would give me much pleasure to instruct any party wishing to use the process, in all the details of its management. I would suggest that a competent person be made master of the whole matter, for the purpose of afterwards lecturing in the mining and quarrying districts, and of teaching workmen to make and use the apparatus; to learn this requires no great stretch of intellect. I have found parties of sappers and miners made perfect masters of the subject by practising with the battery a few hours under my guidance. I must repeat, that its use will not only give security to the workman, but also save much money to the master; but to return to our apparatus.

For the purpose of conveying the electricity from the battery to the rock, a copper wire is used, which must be covered with cotton thread or twine, for the purpose of insulation,—that is to prevent the electricity passing in any other direction than through that part of the wire immersed in the powder, which, being heated by the passage of electricity, fires the charge. In order to economise the electric

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fluid, this part of the wire is made very thin, or what is better, a short piece of fine steel wire is attached to the copper conductor; steel wire is to be preferred, because it is easily heated, and scintillates by the passage of the electric fluid through it.

But as fixing such a piece of wire upon the main conductor for every operation would be troublesome, a cartridge is used, which can be attached to it in less than a minute; this cartridge consists of a tin tube, about two inches long and half an inch in diameter, in which is fitted two wires connected together in the tube by a fine steel wire, a quarter or half an inch longer; the tube is then filled with gunpowder and closed by a cork at both ends, which may be further secured by varnish, should it it be requisite to fire the charge under water; the ends of the wires projecting from the tube are to be attached to the long copper wire before described, as the main conductor. The cartridges are made in this form for the saving of time in blasting, as the men can prepare a number of them prior to the commencing of their operations on the rock, and being well corked and varnished, they may be kept any length of time without sustaining injury.

I have alluded to my new process of tamping; one part is based upon the curious fact, that if a tube of small diameter and moderate length be filled with dry sand, it will require an immense force to drive out the sand with a rammer; indeed so great is the resistance, that if the tube be two feet long and about one inch diameter, no force that can be applied will drive the sand out, the tube will more readily burst than the sand give way; this peculiar property in sand can be applied with great benefit to actual practise; for in tamping, the dangerous and tedious process of ramming down stones and gravel may be abandoned, and the safe and ready one substituted, of merely pouring dry sand into the hole, which requires no ramming; the operation is performed in half a

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minute, whereas ten or twenty minutes were often consumed in ramming down gravel or stones.

Another improvement I have found to be of great value, and this is simply to leave a space between the charge of powder and the tamping stuff; this space, which of course contains air, has the effect of increasing the action of the powder upon the rock, and also of securing the tamping stuff from all chance of being blown out by the force of the explosion—an accident which frequently happened in the old plan of tamping, to the waste of the entire charge of powder. I can almost venture to assert that, by the use of sand, tamping and the maintainance of a space of twelve or eighteen inches between it and the powder, no charge would blow the sand out unless the rock was absolutely unrendable. The effect of allowing a space to exist between the tamping and the powder, may be exemplified when a bullet is not rammed down upon its charge in a musket, for in this case the firing of the musket seldom drives out the bullet, but will rather burst the barrel; and were the bullet near the muzzle, a very small quantity of powder would be sufficient to produce this effect. I have heard sportsmen assert that the resistance offered by the mere plugging up for an inch or two of the muzzle of a fowling piece, by so slight an obstruction as snow or soil, has been sufficient to cause the bursting of the barrel. This singular fact is of easy explanation, and its necessary existence can be fully proved by mathematical demonstration, into which it would be out of place to enter at present; it is sufficient for our purpose to know that in all blasting operations where these improvements have been carried out—which they have been in many hundred cases—in no one instance has it happened that the tamping stuff has been blown out, prior to the rending of the rock. I call your attention most particularly to these improvements, because they are a source of great security to the work-

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man, as well as of gain to the master, and may be employed independently of the use of galvanism, being equally effective as respects resistance, whether this or the old fuse be used.

One great advantage, gained by the use of galvanism, and which cannot be attained by that of any kind of fuse or match whatsoever, is the certainty with which any number of charges may be fired at the same instant of time; for suppose it were attempted to fire eight or ten charges simultaneously by the aid of fuse, it would be absolutely impossible so to arrange their length as to cause an ignition of all the charges at the same moment, and if the explosions are not absolutely simultaneous, no advantage is gained over the firing of these several charges at distant intervals of time. But when galvanism is used, there is a complete simultaneity of explosion, because electricity travels at such a prodigious rate, (200,000 miles in a second,) that its transit from one hole to another in the rock is to us instantaneous. We gain much by rending a rock in this manner, for the fracture runs in one continuous line, and a far greater quantity of stone is torn off than could be done by the same quantity of powder, if fired at distinct intervals; indeed, the amount of rock that can be rent with a small quantity of powder by these simultaneous explosions, is more than persons would believe, had they not witnessed it. I had at first considerable difficulty in contriving the apparatus to ensure a certainty of firing many charges at once, but every obstacle has now been overcome, and the practice is perfectly easy. Another advantage gained by the use of the galvanic cartridge, is the ignition of all the particles of powder in the main charge at once. It is perhaps unknown to some of you, that gunpowder does not explode with flame and gas; on the contrary, it burns progressively—thus, when a gun is fired, many grains of powder are blown out unignited and untouched

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by flame, and of course the expansive power of this part of the charge is lost. Many other facts might be adduced to prove that powder burns progressively: if a mass be fired on the surface, an appreciable quantity of time elapses before the lower particles are ignited, and if this occurs in the bore hole of a rock, (and it always does happen on the old plan), the quantity of powder effective towards rending the rock is a small part of the whole charge, because but a small portion is expanding at one instant, Now, if by any means we can ignite the whole of the charge at once, then we have its full effect developed, and a much smaller quantity of powder will be necessary to produce the same results. I may liken this phenomenon to the exertions of one thousand men in pushing down a wall—if each individual exerts his effort at a different moment from either of his companions, we have but the effort of one man to overset the wall, and it stands in perfect security; but if the one thousand men combine their strength into one simultaneous effort, then we have a one thousand man power against the wall, and down it falls; so is it with the charge of powder in the rock, if a portion only is burning at one time, it is the expansive force of this portion only that is available; if the whole be exploded at once, then we have the fullest possible effect. This firing of every particle of powder at once is obtained by the use of the galvanic cartridge, which pours a volume of flame into the body of the charge, and consequently every particle is ignited. It is to the use of these various improvements that the extraordinary saving of powder by this new plan is to be referred. As I before stated, one gentleman says that he finds 1lb. of powder as efficient in this way as 10lb. is on the old system. I only ask a trial for your own sakes. I gain nothing by it, but the pleasure of knowing that I have been instrumental in giving security to the workman, and of pointing out a mode of gain to the master.

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When a rock is to be rent by this new system of operation, a hole is first bored, of the requisite depth and diameter, then cleared and dried in the usual manner. One-half of the requisite charge of powder is now to be poured in, and on this is placed the galvanic cartridge, whose wires reach to the surface of the rock; then pour upon the cartridge the remainder of the powder; let a wad of straw or oakum be pressed into the hole until it is at a point about two feet from the powder, then upon this wad pour in dry sand; attach the cartridge wires to the main conducting wires; let all the men retire to a place of safety, carrying with them the battery cord, which may be of any required length; pull this cord; the battery is thrown into action; the electricity runs through the fine wire, fuses it, ignites the charge, and the rock is rent. Such is the simple process, which requires far less time than the old method, and is one of perfect safety during the whole of the operation. In the sinking of shafts, the use of galvanism will be found most valuable, as the workman can be drawn up in perfect safety, whereas, when the fuse is used, he has to remain suspended several minutes above the burning train, and the whole may explode before he gains the surface, causing certain death. Such an accident has frequently happened, to my own knowledge, and I have too often heard of its occurrence.

I need not take the trouble to point out the many cases in which this process may be the means of saving human life; for those conversant with mining and quarrying operations must now be well aware of its great value, and in subaqueous explosions galvanism is indispensable. I have expended much time and money in bringing it to its present perfection, but I shall consider myself amply repaid if it be the means of saving one fellow creature from injury.

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT AN EXTRAORDINARY MEETING, HELD IN THE MANSION HOUSE, DONCASTER, AUGUST 1st, 1843.

An Extraordinary Meeting of the Society was held in the Mansion House, Doncaster, on the 1st of August, 1843, in connexion with the Annual Meeting of the Yorkshire Agricultural Society. The Right Hon. Earl FITZWILLIAM, the President of the Society, in the chair.

The following gentlemen were elected Members of the Society, viz :—

CHARLES WOOD, Esq., M.P.
WILLIAM ALDAM, Esq., Warmsworth.

The Rev. Wm. Thorp then read the following Paper :—

ON THE INDICATIONS WHICH ARE GUIDES IN JUDGING OF THE FERTILITY OR BARRENNESS OF THE SOIL.—BY THE REV. W. THORP, OF WOMERSLEY VICARAGE.

Few observing people travel through a country without forming some opinion respecting its productiveness or barrenness, while to the landlord and tenant these indications are of the first importance ; for not only does the former let, but the latter takes, his land upon an assumed value, whether correct or incorrect ; and, therefore, if there are any fixed principles respecting the value of soils, which can be relied upon as criteria, it will be useful and not unworthy of the Geological and Polytechnic Society to endeavour to discover

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them. The Royal Agricultural Society of England, perceiving the importance of this subject, has recently offered a prize of £50 for an essay on the indications which are *practical* guides; for, say they, "Many attempts having been "made to explain the productiveness of the soil by chemical "or physical causes without any decided result, it appears "desirable to assist the researches of natural philosophers, "by making them acquainted with those obvious signs, "whether of colour, consistence, or vegetation, by which "farmers and surveyors are enabled to give at once a "practical opinion upon the probable nature of land which "they inspect."

I do not, however, purpose to confine these observations to the obvious signs named by the Royal Society, because there is no single sign which is infallible under all circumstances. Some are more to be relied upon than others; while a Chemical or Geological sign of easy application, becomes as much a *practical* sign as either that of colour, consistence, or vegetation.

1. Respecting the *Colour* of soils, which is variable on all descriptions of land. The darker soils, rich in vegetable matter, are usually esteemed good; yet some of those, inclining to be peaty, although of this colour, are infertile. Sandy soils, which after rain remain of a light colour, are in general accounted unproductive; yet some of the Wold soils, which contain many flints or white pebbles, are of this colour after rain, and, nevertheless, are of fair quality. Again, at Bentley and Arksey, near Doncaster, there exists excellent land of a yellow colour, while there is other there equally good of a dark blue colour. The productive soils of the Green Sand below the Chalk are green, while those of the New Red Sandstone are red. Therefore colour alone, however valuable, cannot be relied upon as a criterion of the quality of land.

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2. *Consistence* is a valuable indication; for upon the degree in which it exists depends the capability of the soil to produce particular crops,—as wheat and beans upon the stronger,—turnips, barley, &c. upon the lighter soils. The labour required upon a farm, the necessity of summer fallows, the use of lime, &c., all in a great measure depend upon the tenacity of the land. The amount of consistence at all periods of the year, and under all circumstances, is not easily discovered; for some of the light Magnesian Limestone soils, when trodden with sheep after Christmas, retain immediately after rain whole sheets of water, and a stranger then would account them tenacious. Some soils, if ploughed in a wet state, appear more cohesive than they really are. Again, others which a few years ago were of the strongest description, are known to be now, by drainage and cultivation, growing turnips equal in quality to those of lighter soils. Some of the sandy soils fall to a shapeless powder when perfectly dry, yet regain a certain degree of cohesiveness when in a wet state. Moreover, the consistence of the *subsoil* is of equal importance with that of the soil; for upon its pervious or impervious nature depends the comparative wetness or dryness of the soil; and upon the former, of course, the necessity of draining. A general knowledge of subsoils, however, can only be derived from the relation of the subsoil to the stratum from which it is derived, and the local variation to which the latter is subject.

3. *The Vegetation* is another valuable criterion of the quality of land. It may, however, lead to considerable deception; for upon the same soils and the same quality of land every person must have remarked the great difference between a well cultivated farm and a bad one; and it is generally supposed that the value of the land of the well cultivated farm is proportionably increased. But this proposition must be received with some limitation, for the question must be

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determined by the mode of culture, &c, with which the superior crops were obtained. Of two farms having the same soils, and equally luxuriant crops,—the one raised by oil cake, manure, and bones,—the other by rape dust, guano, nitrate of soda, or by artificial manures,—the farm got into condition by the former is of much greater intrinsic value, and will be cultivated at less expense for the future, than a similar farm producing equally good crops obtained by artificial manures. By not attending to this point, we neither know the maximum producing point of any particular soils, nor the lowest rate at which any particular crop may be produced. Again, upon the shallow sandy soils, as well as upon the clayey soils in Yorkshire, there are this year above average crops, which might for the time being mislead the judgment respecting their value. The value of permanent grass land is also liable to be mistaken. There are innumerable instances of grass fields, upon naturally superior soils, having become greatly deteriorated in their produce by bad management, and which, to judge from the vegetation, would be pronounced inferior land; yet these swarths, if ploughed up, will produce excellent crops of grain and artificial grasses. Again, upon the Chalk Wolds and the Magnesian Limestone, only very small portions, (those which contain less than five per cent. of alumina,) produce good crops of grass; so that upon these formations, land of fair or average quality might be condemned on account of the inferior grass land contiguous to it. The vegetation, however, affords other signs, which may with confidence be relied upon; as the timber growing in the hedge-rows, whether it be full grown or stunted—of what species—if covered with moss or lichen—if leaning in one direction; likewise the weeds and plants growing in the fields and hedges, as well as those in the lanes and roads adjoining the land, have their value as criteria.

These three signs, viz., colour, consistence, and vegetation,

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are named by the Royal Agricultural Society as being pre-eminently indications of the value of lands; yet there are others of equal if not of greater consequence; for example—1st. *A knowledge of the Geology of the land* is of the first importance; that is, not only a knowledge of the range and extent of each formation and its sub-divisions, which may be called Geographical Geology; but also how far, and to what extent, the various lands depend upon the substratum for their soil, and the local variations in the Chemical or Mineralogical character of the substrata themselves: this may be called the differential Geology of soils. For not only do the qualities of land vary from one formation to another, but upon the same formation there is frequently considerable difference in the quality of land, depending upon Chemical difference in the substratum, or upon an intermixture of foreign debris derived from other strata. 2nd. *A Chemical investigation* of the soil and subsoil will frequently afford most useful indications respecting the value of land. It may be laid down as an axiom, that a soil to be fertile should contain all the Chemical ingredients which a plant can only obtain from the soil, and Chemistry ought to be able to inform us, in unproductive soils, what ingredients are wanting. It also is able to inform us if any poisonous substance exists in the soil, and how it may be neutralized,—when lime, marl, and chalk, are to be used, &c.*

* Mr. Brakenridge, of Bretton Lodge, who has extensive practice in land valuing, informs me that a *mechanical analysis* of the soil affords him much assistance; and he has found, in soils free from stagnant water, "that in a "mechanical analysis, the larger the proportion which remains suspended in the "water, the greater its powers of production will be found, and the less manure "it will require;—he has found that the best soils are those which, when diffused "and well stirred in water, and allowed to stand for three minutes, from 20 to 30 "—say 25 per cent. is carried off with the water of decantation; when 30 per "cent. and upwards is decanted off, the soil becomes retentive of water, and "consequently wet; when less than 20 per cent.—say only 16 per cent. and under "is carried off, it becomes too porous, water passes through it too rapidly, its "soluble matter is washed off into the substratum, and it has a strong tendency "to become thin and sterile."

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The Royal Agricultural Society say that Chemistry is unable to explain the productiveness of soils. But why is she unable? One reason is, that, supposing every thing required by the plant to be present in the soil, yet, if the soil be either too wet or too dry, too cohesive or too loose, the plant will not flourish; and Chemical analysis does not declare this; for it affords no information respecting the mechanical division in which substances exist in the soil. Again, the Chemical analysis of soils, to be worth any thing, must be conducted with more rigid accuracy than those published by English writers: to detect one cwt. of gypsum in an acre, there would be only one quarter of a grain in a lb. of soil, or in 100 grains, only three and a half thousands of a grain ($\frac{35}{10000}$ or .00035 grains): or, to discover if sufficient alumina existed in a field for the production of red clover, there must be ascertained if it contained .00001 per cent. (one hundred thousandth.) The analyses, even by Sprengel, do not afford us the quantity of nitrogen in each soil, or the capacity of the soil for this substance, while it is well known that most manures, as well as the different kinds of food, are valuable in proportion to the quantity contained in them; and it is highly probable, *cæteris paribus*, that the quantity of nitrogen found existing in a soil, and the capacity of the soil for containing that substance, would afford an easy indication of its immediate fertility, and also of its requiring great or small quantities of nitrogenous manures in its future cultivation.*

Chemistry, however, outsteps her province when it attempts to explain how vegetable productions are formed in the plant by Chemical forces: for the recent discoveries of Schwann, Henle, and Schleiden, prove that all the functions of the plant are performed by the means of simple vesicles and cells—that absorption, assimilation, fixation of carbon from the atmosphere, respiration, exhalation, secretion, and

* The celebrated Black Earth of Russia contains 2.45 per cent. of nitrogen.

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reproduction, are all effected by single cells, of which the lower plants almost entirely consist;—that the cell absorbs alimentary matters through the spongioles of the root, and that the fluid received thus undergoes the first steps of the organizing process; that gum and sugar are converted into the organizable portion of the nutritious sap by the cells of the leaves. The starchy fluid in the grains of corn is rendered capable of nutrition to the embryo by the development of successive generation of cells, which exert upon it their peculiar vitalizing influence. Albumen is converted into fibrine by the vital agency of cell life, *i. e.*, cells are produced which do not form an integral part of any permanent structure in the plant, but which, after attaining a certain maturity, reproduce themselves and disappear. Hence it may be stated, that all the vegetable productions which are formed in the plant, are effected by a series of vital actions through the agency of cells, and even bones and teeth are all formed from metamorphosed cells. Dr. Bennett says, "If this be true, "and there can be little doubt, it obliges us to modify our "notions of organization and life. It compels us to confess "that vegetables and animals are not simple beings, but "composed of a greater or less number of individuals, of "which thousands may exist in a mass not larger than a grain "of sand, each having a vital centre and separate life, inde-"pendent of those around it. Each of these individuals or "organized cells should be regarded as a living being, which "has its particular vital centre of absorption, assimilation, "and growth, and which continues to vegetate, to increase, "and undergo transformations, as if it were an isolated indi-"vidual. At all events, a knowledge of the existence of the "cell life of plants will explain several phenomena respecting "the vegetation, growth, and ripening of corn, and may "hereafter lead to some valuable practical results."

The Climate, Elevation, and Exposure, are not to be neg-

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lected. Upon the higher portions of the Wolds, crops suffer much from elevation and exposure; while in the western portion of Yorkshire, upon the moor edges, the harvest is usually a month later than in the central parts of the island.

A moderate Depth of Soil in general is a favourable sign, although some of the shallow soils on the New Red Sandstone and on the Wolds are very good.

I shall now briefly apply these indications of fertility over the different geological formations of Yorkshire, and it will be found that each lends aid to the other, and that a person will be able to ascertain the value of land in proportion as he is able to appreciate the collective evidence afforded by them.

1. Upon the Chalk Wolds of Yorkshire there are two distinct qualities of land—the shallow and the deep land. Upon the deep land neither wheat nor barley are produced in perfection, the former *night-ripens*, and the latter is not of a good sample. The land is also said to be of better quality where pebbles or boulders are found. The *colour* of both kinds of soil is much alike, yet as the deep soils are improved and rendered more firm by chalking, *consistence*, if positively existing, becomes a favourable sign; so also is that of a good *vegetation*, if used under the precautions before named. And a *chemical* investigation shows that the difference between the good soil and the inferior, is owing to the presence of more lime in the good soil—the deep containing only from 1 to 2½ per cent., while the good contains as much as 7 per cent.; and *Geology* explains why the one soil contains more lime than the other, and how both are geographically disposed;—for the shallow wold soils exist only where large bodies of water have excavated the chalk rock itself, which contains 90 per cent. of carb. of lime; and as fresh pieces of chalk rock are constantly ploughed up, the soil contains more lime. In the map of Hull and its environs of ten miles round, the

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east and west shadings indicate in the valleys very nearly the extent of the shallow land. The occurrence of pebbles and boulders merely indicates the places where currents of water have been in action, and they are therefore only found on the good lands. The climate, elevation, and exposure, are likewise to be attended to over this district.

Beneath the Chalk come the beds of *Oölite*, concerning which I shall simply quote from a valuable paper by Sir J. V. B. Johnstone, Bart., F.G.S., *vol.* 1. *p.* 271, *Journal of the Royal Agricultural Society.* He there states that having observed great variations in the soils of his estate, not only on the hill sides, but also upon the table land, Dr. Smith offered a solution of the difficulty by a reference to Geology —and the result obtained clearly demonstrated *that the value of each field*, and the mode of cultivation already adopted, corresponded to the variations of the strata, and were limited by the areas which these occupied on the surface; thus showing that the geological character of a country, when accurately understood, pointed out at once the natural value of the land, and the system of cultivation best adapted to it. Again, Sir John Johnstone says, "when on descending the "hill sides, it was found that there were certain fields which, "whether towards the north or south, whatever the aspect, "whatever the local circumstances, invariably produced "good wheat, it was a triumph for agricultural geology to "discover that these fields were invariably upon the Oxford "Clay, or rather were the lower beds of the Calcareous "Grit become mixed up with that formation."

The *New Red Sandstone* formation in Yorkshire is one of great complexity, and each of the signs before-named, whenever available, is necessary for determining the relative value of any given portion. The great difficulty is, that upon the central plain of Yorkshire, coloured as New Red Sandstone, are found alluvial, diluvial, and lacustrine deposits of

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considerable extent and thickness, each of which completely changes the agricultural character of the original strata.

The formation itself scarcely makes its appearance in the West-Riding. It consists of variegated marls in the upper portion—the only place where they can be seen is at Holme, on Spalding Moor—and of variegated sand or sandstones in the lower, which are covered up from Hodsock Park, near Blyth, to Green Hammerton, twelve miles north of York.

Among the overlying beds are, first, the *Alluvial* of the rivers Don, Went, Aire. Those of the Don, as at Bentley, Arksey, Kirk Bramwith, Thorne, are exceedingly fertile, producing, with little manure, large crops of grain and excellent feeding pastures. It would be a most useful thing to really determine why these alluvial soils, with only once liming and manuring in the four years, produce great crops, while upon the Magnesian Limestone, and many other soils, manure has to be applied to each crop.

There are also the *Gravel or Diluvial Soils*, which have an extensive range from Doncaster southwards into Nottinghamshire. There are also those extending from Snaith to Ferrybridge; and those of Selby, Hambleton, Hough, &c.; among which are some very superior lands, as Doncaster Field, Snaith Field, Birkin, &c.

The *stronger soils* extend eastward from Owstone, Askern, and Womersley, to Goole. Draining is now being adopted upon this portion, so that there are many instances of farms formerly let at 5s. to 7s. per acre, now let for 20s.; and therefore, these may be said to be progressively increasing in value, while, on the other hand, small farms are general, and have upon them, as a consequence, men of limited capital; few turnips are grown, no stock kept, little manure made, of which, frequently from the badness of the homesteads, one-half evaporates or runs out of the yard.

Upon this great tract of country there is every variety of

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colour, from blue, grey, yellow, dark brown, to light and dark red, so that colour alone (for there are all qualities of every colour) is of little value as a diagnostic sign. The *consistence* of the soil, and its depth when good, are signs generally applicable. Upon the gravel beds there are occasionally local beds of clay, which hold up the water, thus producing a wet soil upon an open gravel, which requires draining. A soil easily rendered firm by sheeping is a favourable sign of sandy land. Upon the clayey soils of this plain it is required that there is a capability of draining them; for large sums of money have been paid for veining up main drains from Goole, which yet afford only an imperfect outlet. *Vegetation*, as a sign of fertility, must be used with great caution; for both the sands and clays of this district are much under the influence of seasons. This year they have both above average crops upon them. The farms situated upon the sands and gravels were originally of the same value, and it is probable that if there be any difference in them, it has arisen from superior management.

Geology is with difficulty applied in determining the value of land upon the whole of the formation, except the larger boundaries of geographical Geology just mentioned. In the gravel there is no regular disposition of strata. It is one amorphous mass of boulders, with portions of red sand intermingled. Some of the stronger clay beds, between Askern and Goole, are exceedingly thin; and, therefore, in order to make Geology available, it would be necessary to have, as in mining, a knowledge of every minute bed, which can only be obtained by boring, there being no natural sections upon this extensive plain.

Concerning the *Magnesian Limestone*, and the qualities of land upon it, I may refer to a former paper read before this Society. I would, however, simply observe, that *colour* is of little value, the whole of the soils being red and yellow, and

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all more or less red after rain. That *consistence* is a valuable sign, is shown by the fact that the stronger soils, or those which contain not less than 5 per cent. of alumina, will grow permanent grass and the oak; and that the firmer, or those rendered so by management, will preserve red clover from the frost; while others more "deaf" and pulverulent, will not grow red clover at all. Contrary to the Wolds, the shallow soils are much inferior to those of moderate depth. The *vegetation* on the south side of Doncaster is a certain criterion that the land on that side is superior to that of the north side. *Geology* explains why, as upon the Wolds, shallow soils exist, for they are only found where large bodies of water have passed over the rock, and worn it out into valleys; while on the south side of Doncaster, the superior soil is caused by an admixture of sandstone pebbles brought down the course of the Don, at no distant period of the earth's history.

In the Coal or Carboniferous series there is every variety of *colour* in the soil, in its *consistence*, and in the *vegetation* of particular districts; and a casual observer would find no order or regularity. In some parts, even single fields lying in east and west lines are of different value. But the prevailing agricultural characters are strictly dependent upon geological causes, and if Geology is unable, from want of section, to explain the agriculture of the country upon the New Red Sandstone, she alone is able to give any rational explanation of the great variety of land observed west of the limestone, between either Hickleton, Hemsworth, or Wakefield, up to Penistone. Now all the strata of the Coal series rise at a rapid angle to the west, and this at a greater rate than the surface rises; the various beds consequently come to the surface, and extend across the country in north and south lines; therefore, if similarity of soils from identity of strata exist, they will be found to extend from north to south.

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In the first place the upper beds in the Coal field have upon them some of the most valuable lands in Yorkshire, which consist of grazing pasture and most excellent wheat soils; as at the Heath, Nostell, Badsworth, Lord Galway's, at Felkirk, and at Mr. Foljambe's estate at Brierley; further south, Mr. Fountaine Wilson's land, at Melton, lets at 30s. to £3 per acre. All the borings and sinkings afford a list of sandy binds, or clays mixed up with sand, which do not usually require draining.

Below these, and further west, there are three thick beds of Sand Rock, which come to the surface, and afford the lands of Sandall, near Wakefield, Woolley Park, Monk Bretton, Wombwell, Wath, &c., light sandy sheep soils, the agriculture of which, for twenty to thirty miles, corresponds to the rocks upon which each farm is located.

Below these four rocks, binds consisting of more Clay with less admixture of Sand prevail, and occupy the largest portion of the Coal district, and contain the most valuable coal mines, some of which are worth £400 per acre. Even some of the beds, as the muscle band ironstone, with its coal, can be traced when only 20 to 60 yards deep, by the very wet and clayey lands above it.

The Flagstone and Millstone Grits at the bottom of the series then come to the surface, and their productiveness is limited by the elevation to which they rise, for they form some of the most elevated regions. When sheltered and in valleys, there is seen upon them some excellent meadow land, also good wheat and barley: indeed Penistone seeds for laying down grass are celebrated. But upon the western heights, 1200 to 1800 feet above the level of the sea, the crops, from the severity of the winter, are cut up, and hay harvest is commonly not completed by the 12th of August, and the oat crops are frequently not housed before November.

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Here, then, upon the Coal series of Yorkshire, although consistence of the soil, vegetation, and the geological relations of soils, have each their respective value as marks of the value of land; yet all these are modified and are subordinate to (in the western districts) the climate, aspect, &c., of each particular farm.

Such, then, is an outline of those indications which are guides in judging of the fertility or barrenness of soils; with examples of their application through the whole of Yorkshire; any one of which is not to be used to the exclusion of the other, whenever it is practicable to use them all. The Royal Agricultural Society, however, gives preference to those obvious ones which are called practical, for they say—"by "these, farmers and surveyors give at once a practical "opinion upon the probable nature of land which they in-"spect." I do, however, maintain that whenever a person has a knowledge of all the signs, i.e., the chemical and the geological, in addition to those more obvious ones mentioned, and is capable of applying them, he will form a more correct opinion than another who relies only upon those more simple; and he will find in innumerable cases that the geological signs will *explain why* the chemical ones are exhibited; while both combined will again show why a difference of colour or consistence exists, which again will explain the difference of vegetation upon various soils.

The whole of this subject is well illustrated by what has occurred in the practice of medicine. Thirty years ago, the only signs of disease in the chest, were learned from states of the pain, the skin, the tongue, the breathing, cough, and the sputum. It is now, however, well known that in inflammation of the substance of the lungs, (pneumonia) one-tenth of the cases are entirely free from pain—that one-seventh show nothing abnormal in the breathing—and in one-sixth the cough and expectoration are simply catarrhal; so that a

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person may have a violent inflammation of the lungs, and yet be entirely without pain, have no difficulty of breathing, and only a slight cough. And, under these circumstances, the pulse, the skin, and the tongue, are the only remaining fallacious signs to indicate not only the seat, but the nature of the complaint; and it may be truly said, that a physician who has a knowledge of these signs only, is as much liable to be in error respecting diseases of the chest, as a person who examines in a soil only the colour, consistence, and the vegetation, for indications of its fertility.

Laennec, however, by the discovery of other physical signs, has done for medicine, what Chemistry has for Agriculture, added greater precision to our knowledge. He found by the aid of percussion and auscultation, that five cases out of seven, present in pneumonia in the first stage of invasion: 1. A remarkable feebleness of breathing. 2. That in nearly all cases under fifty years of age, during the second or inflammatory stage, there is a remarkable crackling in the lung, (a crepitant rhonchus,) resembling salt thrown into the fire, and perfectly diagnostic of the complaint. 3. That in the third stage, the respiration is bronchial throughout the lung, accompanied by dulness upon percussing the walls of the chest. Then the labours of pathologists were brought to bear upon this subject, and just as geology is able to explain why variations in the colour, consistence, and vegetation of soils do take place, as well as most of the chemical and mechanical differences; so *the anatomy of diseased parts* (pathological anatomy) has been made subservient to the explanation of all the symptoms attending disease, and has become the very basis of an enlightened view of therapeutics. It informs us in the case before us, that in the first stage of inflammation, the blood vessels are loaded with an inordinate quantity of blood, the lung consequently congested and tumefied, and consequently the first physical sign of *feebleness of respiration is explained;*

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hence, to unload these blood vessels is indicated as a means of cure. That in the second stage, the distended blood vessels unload themselves into the substance of the lung, by which the ingress of air into the cells is further obstructed, while the viscid secretion of the mucous membrane, simultaneously inflamed, only yields to the air forcing its way through it in successive bubbles; therefore the *crepitant rhonchus* or crackling is explained; and hence general antiphlogistic treatment. In the third stage, the fluid effused from the blood vessels becomes organized, the lung consolidated and rendered firm as liver, and the air cells obliterated by a semi-solid albumen; hence dulness on percussion; and the bronchial respiration is heard, owing to the firm substance of the lung having become a better conductor of sound. It is needless to say, that each of these stages of disease requires a different treatment, and that, in the last stage, where the tissue of the lung is disorganized, large depletions would be certain death. It is evident, therefore, that Geology and Chemistry afford as much information really practical, as auscultation and pathology do in medicine; and if by the question of what are *practical* indications of the value of soils, asked by the Royal Agricultural Society, (and I am happy to see several distinguished members of that Society present,) they mean only those of colour, consistence, and vegetation, they will receive an answer as much empyrical, as that given by a physician who declares his diagnosis and mode of treatment in diseases of the chest, from a consideration of only the more external rational symptoms, to the neglect of the physical and pathological.

The fact is, that Agriculture is closely allied to the general sciences, and to exclude any of these from our deliberation, is to contract our view of the grand operations of nature concerned in all her productions.

It is true that the descriptive sciences always precede the

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general sciences; in the former we seek the differential characters of facts; while in the latter we combine them, and connect them together by analogies; hence to describe a soil in its variation of colour, consistence, and vegetation, as in anatomy to describe the blood vessels, nerves, muscles, &c., must precede all knowledge of the capabilities and physiology of both. And in order to predicate respecting the indications of the fertility of soils, they must be considered in their more general relations; we must discover their connection with Geology, Chemistry, and with Physiological Botany, and the more we know of each of these correlative branches of Agriculture, the more we shall be able to appreciate their bearings upon her practical operations, and to give a philosophical explanation of the different branches of that most important of all sciences, viz., that from which the human species derives all its comforts, and by means of which its race is perpetuated upon the surface of the globe.

On the motion of PHILIP PUSEY, Esq., M.P., seconded by Lord MORPETH,—The thanks of the Society were voted to Mr. THORP, for his Paper.

The Earl SPENCER moved, and J. W. CHILDERS, Esq., M.P., seconded a resolution,—That the thanks of the Meeting be given to Earl FITZWILLIAM for his services in taking the Chair.

At a MEETING OF THE COUNCIL, held at the Committee Room of the Mechanics' Institution, in Wakefield, on the 27th September, 1843: present,—The Earl FITZWILLIAM in the Chair, Mr. Thomas Wilson, Mr. J. G. Marshall, Mr. West, Mr. Holt, Mr. W. T. Hall, Mr. George Wilson, Mr. Stansfeld, Rev. W. Thorp, Mr. Hartop, Mr. Briggs, and Mr. Clay.

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The Secretary reported that a Joint Meeting of the Committees appointed by the Geological and Polytechnic Society and by the Leeds Philosophical and Literary Society, was held in Leeds, on the 23rd September: present,—Rev. R. W. Hamilton in the Chair, Messrs. J. G. Marshall, T. P. Teale, W. S. Ward, Wm. West, Thos. Wilson, and J. T. Clay; and that after a long conversation concerning the removal of the Museum from Wakefield to Leeds, the following minutes were unanimously agreed upon as a basis for the proposed arrangement:—

That such an arrangement as is proposed, is regarded by us as very desirable.

That the Curators of the two Societies agree in the appointment of the Sub-curator of the Leeds Philosophical and Literary Society, the latter Society receiving any amount of compensation which may be due in respect of the increased labours of the Sub-curator.

That the Geological Curator of the Leeds Philosophical and Literary Society be, ex-officio, one of the two Curators of the West Riding Geological and Philosophical Society, during the proposed arrangement.

That the notices to terminate the proposed arrangement, be one full year's notice by either party.

That the sum of £30 per annum appears a reasonable amount to be paid by the West Riding Society to the Leeds Society for rent, and compensation for extra labour, &c.

That the whole expense of removing the Museum from Wakefield, and its setting up in the Philosophical Hall, be borne by the West Riding Geological and Polytechnic Society, as well as the expense of its further alterations.

That the right of entry and admission to the united Museums be the same to the members of both Societies.

The foregoing minutes having been fully discussed, it was unanimously resolved:

That the proper steps be taken to make suitable arrangements for the removal of the Museum to Leeds.

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE FIFTH ANNUAL MEETING, HELD IN THE MECHANICS' INSTITUTION, WAKEFIELD,

ON WEDNESDAY, SEPTEMBER 27TH, 1843.

The Right Hon. Earl FITZWILLIAM, President of the Society, in the Chair.

The Secretary read the following Report of the Proceedings of the Society for the past year :—

REPORT OF THE COUNCIL OF THE GEOLOGICAL AND POLYTECHNIC SOCIETY OF THE WEST-RIDING OF YORKSHIRE, PRESENTED AT THE FIFTH ANNUAL MEETING, ON THE 27TH OF SEPTEMBER, 1843.

During the past year, the proceedings of the Society have been conducted with the usual regularity. At the last annual meeting the number of members was 329. During the year 18 have been elected and 11 have resigned. The list of members has also been corrected by the erasure of the names of several gentlemen, who, from death, removal, and other causes, had ceased to qualify, leaving the number on the books, 299.

At the annual meeting in SEPTEMBER, papers were read by the Rev. W. Thorp—"On the failure of Red Clover on certain soils," and by James Hamerton, Esq.—"On Arboriculture."

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At the meeting held at Bradford, in DECEMBER,—"An Explanation, with Illustrations, of a practical method of determining the qualities of Iron and Steel, and the hardness of the latter," by the Rev. W. Scoresby, D.D., F.R.S.—"On a series of Experiments made upon Iron, manufactured by the hot and cold blast," by William Graham, Esq., Milton Iron Works, and "On the Geometrical Principles of Gothic Tracery," by W. Wallen, Esq., F.S.A.

At the meeting held at Halifax, in MARCH—"On rendering available for Agricultural Purposes, a variety of substances and refuse from Mines, hitherto considered of no value," by H. Briggs, Esq., Overton.—"Observations upon certain Geological Terraces, with some remarks upon Glacial Phenomena," by Mr. D. Mackintosh.—"On the Reciprocal Propelling Powers of Fluids, and certain Rotary Machines upon each other," by B. Biram, Esq., Wentworth.—"On the Process of Blasting, by means of Galvanism," by Martyn J. Roberts, Esq., F.R.S.E.

At the meeting held at Leeds, in JUNE—"Illustrations of the Yorkshire Coal Field," by the Rev. W. Thorp,—"On the Results of Experiments on the Relative Strength of Pig Iron of various qualities, and from different makers, upon bars 12 inches long and one inch square," (second series) by Mr. Chas. Todd, Leeds,—"On the Advantages of Mechanical Force over the Power of Rarefaction in Ventilating Mines and Buildings," by Mr. William Fourness, Leeds,—"On Pumps, for Mining and Engineering Purposes," by H. Hartop, Esq.

An Extraordinary Meeting was also held at Doncaster, on the 3rd of AUGUST, in connexion with the annual meeting of the Yorkshire Agricultural Society, at which a Paper was read by the Rev. William Thorp—"On the Best Modes of Judging of the Fertility of Soils."

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A general feeling of gratification was expressed at the co-operation of the two Societies, which have many subjects of common interest, and the Council look forward with pleasure to the prospect of a future opportunity of interchanging information of a mutually interesting character.

This list of communications, while it indicates the existence, in the West-Riding, of a large portion of that inquiring spirit which so peculiarly marks the present age, must also be highly satisfactory to every supporter of the Geological and Polytechnic Society, as a proof of the advantages resulting from the establishment of an Institution so well calculated to elicit the varied talents of its members.

The Council would particularly call attention to the progress of the line of section taking across the West-Riding: two of the divisions are now completed, namely, that surveyed by Mr. Bull, which includes the township of Mirfield, and the one by Mr. T. W. Hall, comprising the townships of Bretton-West, Crigglestone, Wortley, Notton, Roystone, Shafton, Brierley, and Great Houghton, extending over a distance of upwards of nine miles, and exhibiting a noble instance of the devotion of individual exertion to the advancement of scientific knowledge. It is of much importance that those gentlemen who have so liberally undertaken to perform the remaining portion, should make their arrangements as early as possible, in order that the whole line of the section, with the geological characters marked on it, may be completed before the lapse of another summer.

In the last Annual Report, the Council stated that a resident Curator had been appointed, to take charge of the Museum in Wakefield. This proceeding involved a considerable annual expenditure, and after upwards of a year's experience, the Council do not consider that the increased outlay has been attended by correspondent advantages; and

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while they are anxious to extend the usefulness of the Museum, which now contains a very valuable collection, they do not feel warranted in sanctioning such an encroachment upon the funds of the Society, as this system of management requires. They have, therefore, instituted an inquiry as to the possibility of placing the collection under the care of some Philosophical Society in the West Riding, with the expectation that if a satisfactory arrangement of this nature could be made, means would be afforded which would enable the Council to procure the occasional services of gentlemen of known scientific attainments, and also allow an increased expenditure in collecting specimens.

In conclusion, the Council beg to impress upon the Members of the Society the necessity of continued and active exertion in promoting the furtherance of its objects. The British Association for the Advancement of Science having determined to hold its next Meeting in York, in the autumn of 1844, an impulse will, doubtless, be given to the study of those subjects which peculiarly come under the notice of this Society, and which must be highly advantageous to its interests.

STATEMENT OF THE RECEIPTS AND EXPENDITURE,

From 25th September, 1841, to 25th September, 1842.

DR.	£.	s.	d.
Balance in Treasurer's hands	15	13	9
Subscriptions—			
From 1 Member for 1838..£0 10 6			
,, 7 ,, 1839.. 3 13 6			
,, 33 ,, 1840.. 17 6 6			
,, 154 ,, 1841.. 99 16 6			
,, 51 ,, 1842.. 33 3 0			
	154	10	0
Hon. W. S. Lascelles, M.P.	5	0	0
Sale of Reports	0	6	0
	£175	9	9

CR.	£.	s.	d.
Salary of Curator, one quarter	12	10	0
Printing and Engraving	8	8	4
Printing Reports	46	6	0
Carriage of do.	1	7	8
Postages	8	6	8
Reporting Proceedings	11	10	0
Expenses of Meetings	7	3	4
Expenses of Museum	6	7	2
Ditto extraordinary, for Cases	38	5	0
Rent	15	0	0
Collecting Subscriptions	1	4	6
Purchase of Books and Maps	3	14	0
Advertising	2	0	6
Carriage, Messengers, &c.	1	16	5
Balance in Treasurer's hands	11	8	2
	£175	9	9

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STATEMENT OF THE RECEIPTS AND EXPENDITURE,

From 25th September, 1842, to 25th September, 1843.

DR.	£.	s.	d.
Balance in hand	11	8	2
Subscriptions—			
From 1 Member for 1839..	0	10	6
„ 6 „ 1840..	3	3	0
„ 19 „ 1841..	12	7	0
„ 84 „ 1842..	54	12	0
„ 80 „ 1843..	38	8	0
	109	0	6
Balance due to the Treasurer	2	14	1
	£123	2	9

CR.	£.	s.	d.
Salary of Curator, one year	30	0	0
Printing and Stationery	17	5	0
Postages	6	14	9
Reporting Proceedings	0	11	6
Expenses of Meetings	8	7	3
Expenses of Museum	10	14	11
Rent, one year	15	0	0
Collecting Subscriptions	2	7	0
Advertising	8	17	9
Carriage, &c.	3	14	7
	£123	12	9

On the proposition of the Chairman it was unanimously resolved:—

That the Report and Cash Account be received.

It was moved by Mr. HARTOP, and unanimously resolved:

That the thanks of the Meeting be given to the Directors of the Mechanics' Institution, for their kindness in affording the use of their Hall on the present occasion.

On the proposition of the Secretary the following gentlemen were unanimously elected Members of the Society:—

Mr. JOHN ROGERSON, Doncaster.
Mr. JOHN WILSON, Sheffield.
Mr. J. C. WILSON, Sheffield.
WM. HATFIELD, Esq., Newton Kyme, Tadcaster.

The following Resolutions were passed unanimously:—

Mr. WEST proposed and the SECRETARY seconded,

That Mr. Martyn J. Roberts, F.R.S.E., be elected an Honorary Member of the Society.

Mr. WEST proposed and the Rev. W. TURNER seconded,

That this Society views with much satisfaction the return of the British Association for the Advancement of Science to its birth-place, the city of York, and recommends to the Members of the West-Riding Geological and Polytechnic Society, to assist by such means as may be in their power, in rendering the proposed Meeting of the British Association in York numerous, interesting, and advantageous to science.

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The following gentlemen were then declared duly elected to be the officers of the Society, by the provisions of rule 13:

President.

EARL FITZWILLIAM, F.R.S.

Vice-Presidents.

Duke of Norfolk.	T. W. Beaumont, Esq.
Earl of Effingham.	J. S. Stanhope, Esq.
Earl of Dartmouth.	R. O. Gascoigne, Esq.
Lord Wharncliffe.	G. Lane Fox, Esq.
Lord Stourton.	J. W. Childers, Esq. M.P.
Viscount Milton.	E. B. Beaumont, Esq.
Viscount Howard, M.P.	G. Wentworth, Esq.
Hon. W. S. Lascelles, M.P.	W. Bennett Martin, Esq.
Hon. J. S. Wortley, M.P.	C. J. Brandling, Esq.
Sir F. L. Wood, Bart.	J. G. Marshall, Esq.
Sir W. B. Cooke, Bart.	Michael Ellison, Esq.
Rev. Dr. Scoresby.	T. D. Bland, Jun. Esq.
Rev. S. Sharp.	P. D. Cooke, Esq.
Rev. T. Barnes.	Wm. West, Esq. F.R.S.

Council.

H. Briggs.	Charles Morton.	Rev. W. Thorp.
W. T. Hall.	George Welch.	H. Clarkson.
H. Hartop.	Thomas Wilson.	J. Westmorland.
J. M. Stansfeld.	W. R. H. Johnstone.	Charles Locke.

Secretary and Treasurer.

Joseph Travis Clay, Rastrick, Huddersfield.

Honorary Curators.

T. W. Embleton and Henry Holt.

Auditors.

Benj. Biram and G. W. Chambers.

Mr. West then read the following Paper:—

ON A REMARKABLE CASE OF THE ACTION OF SPRING WATER ON LEAD.—BY WILLIAM WEST, ESQ., HIGHFIELD HOUSE, NEAR LEEDS.

The mutual reaction of water and lead becomes of increasing practical importance as the increase of population and refinement causes us, in the country as well as in towns, to recede from the primitive method of supply,—carrying the pitcher to the spring,—and to substitute pumps and cisterns.

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Though many of the circumstances which influence this reaction are now known to scientific chemists, yet they have so recently been ascertained, and they have found their way so little into purely medical works, and still less into popular treatises, that a short account of some of them may be a proper introduction to the particular case referred to in the title of this paper. No longer ago than 1803, Dr. Lambe, in his "Researches into the Properties of Spring Waters," states that *rain* water does not corrode lead, but that most *spring* waters possess the property of corroding and dissolving lead to such an extent, as to render them unfit for the use of man, and that they derive their solvent power from some of the salts present in such waters. In 1809, Guyton Morveau, from experiments much more scientific and accurate than Dr. Lambe's, came to an opposite conclusion,—that distilled or pure water acts rapidly on lead, converting it into a hydrated oxide (white lead); and that some natural waters, which hardly attack lead at all, are prevented from doing so by the salts which they hold in solution. Morveau is right as to distilled water acting on lead. Dr. Lambe was mistaken.

Dr. Christison, by experiments which I presume are original, and which are detailed at some length in his Treatise on Poisons, 1832, has established with great minuteness, and for the most part with unquestionable accuracy, the circumstances, or at least many of them, which influence this curious and important reaction. He states that distilled water, deprived of its gases by boiling, and excluded from contact with the air, has no action on lead. That if the water contains the customary gases, (oxygen, nitrogen, and carbonic acid,) the surface of the lead loses its polish and becomes white; if the surface of the water be not exposed to the air, the action soon comes to a close; but if the air is allowed free access, the action goes on to a great extent.

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The last circumstance I have often verified, as well as Dr. C.'s correction of Guyton Morveau, that the white powder is carbonate, not hydrated oxide. But I have not found the exclusion of air, or even its separation by boiling, so effectual as it appeared to Dr. Christison. I find, like him, that any of the neutral salts usually contained in natural waters, lessen or prevent the action described. I resume his account, much curtailed, of the action of particular classes of salts.

The preserving power depends entirely on the acid of the salt, not on the base, and those salts are preservative in the highest degree whose acid forms, with oxide of lead, salts of the least solubility, either in water alone, or water containing carbonic acid. When the corresponding salt of lead is insoluble, or very nearly so, an extremely minute proportion of any alkaline or earthy salt acts as a preservative.

Acetates and nitrates are not completely preservative, even in the proportion of one per cent. to the water, or 700 grains in the gallon; phosphate of soda is almost effectually so in the proportion of one to thirty thousand, or about two grains in the gallon. None of the above salts being commonly present in natural waters, they are not of immediate practical importance; but they are material in a scientific point of view, as proving the defensive power to vary according to the solubility of the salt of lead denoted by each acid, the acetate and nitrate being among the more soluble of salts of lead, phosphate of lead one of the most insoluble of neutral salts. Common salt and other chlorides, gypsum and other sulphates, hold a middle place. Dr. Christison seems to have found them defensive in proportions ranging from 1-2000th to 1-4000th, the sulphates being the most effectual.

In those solutions of muriates, sulphates, and carbonates of lime, soda and magnesia, which constitute the greater part of spring waters, I have observed, I think, quite as great

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preservative power as would be inferred from Dr. Christison's remarks. Even rain water, in the ordinary modes of collection, acquires occasionally, according to his observations as well as my own, sufficient saline matter to be quite preservative. But it may be unsafe to trust to this as sanctioning the use of rain water conducted from leaden roofs, or its preservation in leaden cisterns, when intended in either case for culinary uses. He points out, too, a mode in which leaden cisterns, when kept covered, may be and have been acted on while storing water in itself preservative. It is that such water will give out vapour to the atmosphere above; when the cistern is only partially full, this vapour, on any accidental reduction of temperature, condenses as pure or distilled water on the uncovered portion, acts on this, and trickles down to the saline or preservative water beneath. He describes some cisterns the upper parts of which had been corroded in this manner. Minute, accurate, and systematic as were the experiments of Dr. Christison, to which the above abstract does but feeble justice, he has not exhausted the subject. He found the presence of much carbonic acid in the water to counteract somewhat powerfully the defensive effect of the salts. With me this has been less remarkable than with him. I think that I have observed lead partially immersed to be, apart from any condensation of water, more acted on than when wholly immersed. I impute this to a galvanic action between the wet and the dry lead. The question, very material in a practical point of view, how far slight impurities of certain kinds in the lead itself render it more or less readily acted on? has not been scientifically investigated. Dr. C. does not touch upon it. I find Chinese tea lead, which contains tin, to remain bright in such distilled water as rapidly acts on plumber's English lead; but on the other hand plumber's solder, which contains a much greater proportion of tin, was in one cistern more generally attacked than the lead itself.

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And I have been informed that some of the lead of commerce is in fact much more easily corroded than other samples. Even the difference in density between rolled and cast lead may produce some difference in effect.

I met with an instance but a few years ago of how little the knowledge of the true action of water on lead had become known, and of the danger attending ignorance on the subject. A gentleman of some fortune, education, and general intelligence, at whose house I had occasion to call on other chemical business, showed me with great glee a leaden cistern in a dark cellar, into which was conducted the water arising from the condensation of the steam of his cooking apparatus, and in which this water so distilled, was stored for his own special drinking. Suspecting that the usual process must take place, I examined the state of the cistern more closely than he had done, and found at the bottom a deposit of nearly half an inch in thickness of carbonate of lead in loose glistening crystals; the water at the same time showing to the proper tests, decided proof of the presence of some of the carbonate in solution.

I proceed to the case in question, as the immediate subject of this essay. I was applied to in order to discover the cause of, and if possible to provide a remedy for, the corrosion of certain cisterns at a gentleman's mansion. One had to be provided with a new bottom about five years after its erection, and others threatened a like result. The corrosion was not general, like that of a sheet of lead in pure water, but on certain spots there were fungous or efflorescent deposits of carbonate of lead. These were easily removed, and under each the lead was black, without metallic lustre, and so soft as to be easily scraped with the nail into a hollow. When left to themselves, the lead in these spots, in the cistern which perished, was acted on more and more deeply, until they became holes, which caused it to leak. These spots upon the lead were confined to the bottom, but upon the solder they

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were not only more abundant, but they were found upon the solder of the pipes which serve as exit-plugs, at all heights from the bottom. The water, it may be proper to mention, is kept at the same height, almost filling each cistern, by a ball-cock. One peculiarity of the case is that a leaden bath, close to the original spring, is kept filled with the same water, and this bath has remained without injury or repair for, it is said, sixty years. From the spring a portion of the water is forced by its own action on a ram, for about a quarter of a mile, to a covered stone tank in the park.

In this portion of its course it is conveyed through a leaden pipe. The tank being covered, excludes the supposition of decaying vegetable matter, which has been suggested. From the tank to the mansion, probably about the same distance as from the spring to the tank, it passes through a pipe of cast iron. I ascertained by a minute analysis that the composition of the saline ingredients of the water was exactly the same in the three situations, the spring, the tank, and the cistern. It yielded as follows, in the imperial gallon:

Sulphate of Lime	3 grains.
Muriate of Lime	3¼ „
Sulphate of Soda	1¼ „
Carbonate of Soda	8½ „
Total.....	16 grains.

The water from the spring yielded no trace whatever of lead in solution, that from the tank an exceeding minute trace, that from the cistern was more decided.

The water in passing through the iron pipe, brings with it a quantity of iron rust, which when thus carried into the cistern, though easily moved, collects in certain parts according to the eddies in the water, and I think I traced a connection between such collections of rust and the efflorescence and attendant corrosion of the lead. Taking all the circumstances

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together, I cannot doubt that this rust is the cause of the injury complained of. We know that peroxide of iron stands on or near the verge which separates bases from acids, but so decisive an action of this substance on another metal is not, that I know of, elsewhere recorded. Nor have I been able to hear, from plumbers of whom I have inquired, of lead having been thus observed to be corroded into holes.

I suggested for trial, by way of remedy, passing lime water through the iron pipe, in the hope of coating the iron with carbonate of lime, and thus preventing the formation of rust; this was tried, and for a time with some appearance of success, but the rust soon returned, and with it the corrosion; it only remained, therefore, to recommend coating the cisterns either with paint or cement.

Mr. Lucas, of Sheffield, read a Paper, describing the Action of the Atmospheric Railway between Kingstown and Dalkey.

Mr. Hartop read a Paper on Ventilation, and explained the Principle of an Apparatus intended to promote the proper Ventilation of Rooms.

Mr. Hall exhibited the Portion of the Line of Section allotted to him; comprising the townships of Bretton West, Crigglestone, Wortley, Notton, Roystone, Shafton, Brierley, and Great Houghton, extending over a distance of upwards of nine miles.

The thanks of the Meeting were voted to the Authors of the Papers, and to Mr. Hall.

The Secretary read the following notice, which had been laid upon the table, having received the signatures of ten Members:—

"At the next Quarterly Meeting of the Society it will be proposed:—

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"That the Specimens composing the Museum of this Society, be removed into an apartment of the Leeds Philosophical and Literary Society, and that they be kept there as a separate collection, and remain the property of the Geological and Polytechnic Society of the West-Riding of Yorkshire, and be reclaimable at pleasure, on due notice."

It was moved by the Rev. SAMUEL SHARP, and seconded by J. G. MARSHALL, Esq., and unanimously resolved:

That the thanks of the Society be given to the Earl FITZWILLIAM for his able conduct in the Chair, and for his uniform attention to the interests of the Society.

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE TWENTY-FOURTH QUARTERLY MEETING, HELD AT HUDDERSFIELD, ON WEDNESDAY, DECEMBER 6TH, 1843.

The Rev. W. SCORESBY, D.D., F.R.S., in the Chair.

The Rev. Dr. SCORESBY, on taking the Chair, commenced the proceedings of the meeting by remarking upon the great advantages of the Polytechnic Department of the Society, by affording the means of communication between practical men. Many discoveries of the highest order had arisen from the observation of minute circumstances, and he urged the younger members in particular not to refrain from communicating any new observations, from the idea that they were of trifling importance. The investigation regarding the determination of the quality of iron and steel by magnetism, which he had brought before the Society some months since, had been continued, and the course of experiments was now completed. The expectation which he had formed of the utility of this test had been fully realized; in wrought iron he was able to discriminate the quality very accurately, and he had been equally successful with steel; but greater difficulty attended his observations on cast-iron, though a considerable degree of accuracy had been attained. A manufacturer of tools, at Sheffield, had had a quantity of foreign iron put into his hands, which appeared to him well fitted for steel, though much lower in price than that which he usually used; he

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converted it, and manufactured the steel into tools, which were apparently of the best quality; but he was fearful of injuring the character of his articles, and, being still doubtful whether it was safe to send them out to his customers, he requested him (Dr. Scoresby) to examine them, and, on submitting them to the test, he found that although the steel of which they were made was lower by £10 per ton than what the manufacturer had usually employed, it was in every respect of equal quality.

The notice having been read, which had been laid upon the table at the Annual Meeting,

It was proposed by Mr. PITT, and seconded by Mr. Morton, and carried unanimously,

That the Specimens composing the Museum of this Society, be removed to the Apartments of the Leeds Philosophical and Literary Society, and that they be kept there as a separate Collection, and remain the property of the West-Riding Geological and Polytechnic Society, and be reclaimable at pleasure, on due notice, and that the following gentlemen be requested to carry the foregoing Resolution into effect, and that they be appointed a Committee, to make the needful arrangements, viz., Mr. Briggs, Mr. Holt, Mr. Morton, Mr. J. G. Marshall, Mr. Embleton, Mr. J. W. Leather, Mr. Teale, and Mr. Thomas Wilson.

Dr. INGLIS moved, and Mr. BRIGGS seconded, the following resolution, which was carried unanimously:

That the thanks of the meeting be given to the Literary and Philosophical Society of Huddersfield, for their kindness in affording the use of the Hall on the present occasion.

Dr. INGLIS then read the following Paper:—

OBSERVATIONS ON THE DISCOVERY OF COPROLITES IN THE STANLEY SHALE AND FLOCKTON STONE, OR FISH COAL, BY MR. M. SIMPSON, OF WHITBY.—COMMUNICATED BY JAMES INGLIS, ESQ., M.D., HALIFAX.

As facts ought to form the basis of every Geological theory, and as your Society has for one of its great objects the pro-

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motion of Geological Science, I feel satisfied that every fact and practical observation made by Members, or others, will at all times be readily listened to by you, when communicated to the Society.

It is not my intention at present to offer any remarks upon the long contested question regarding the origin and formation of Coal. My object in bringing the present communication before you is simply to add what is considered to be a fact to those already collected upon this subject; and further, to place upon your books the name of Mr. Simpson, your late Curator, as the first discoverer of what have been considered to be Coprolites in our own immediate Coal-formation.

Without, therefore, troubling you with a more lengthened preface, you will allow me to read the few following pages, which Mr. Simpson has written at my request, and has kindly permitted me to present to the Society.

"Having lately," says he, "directed my attention to the remains of Fishes occurring in the roofs of some of the Yorkshire Coal Beds, it has been thought desirable that I should communicate the result of my observations to this Society. It is well known to several of the members that the remains of fishes occur in many of the dark shales of the Yorkshire Coal Series; but I shall confine my observations principally to the beds which form the roofs of the *Stanley Shale Coal* and the *Flockton Upper Bed.*

"The first of these, viz. the Stanley Shale Coal, is about 80 yards deep at Stanley, near Wakefield, and very near the surface on Westgate Common. It underlies the important sandstone beds of Altofts, Wakefield, and New Miller Dam. At about 18 yards beneath is another bed, called Stanley Main Coal, of very variable quality, which, however, on account of its proximity to the Stanley Shale Bed, is of great service in ascertaining its identity.

"The *Flockton Bed* lies about 260 yards beneath the

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Stanley Shale Bed, from which it is separated by the Stanley Main, the Warrenhouse, and the Haigh Moor Coal, including two important beds of Sandstone,—viz. the Horbury and Dewsbury Rock, which overlies the Haigh Moor Coal;—the other, which is, I believe, denominated the Bradgate Rock, and may be seen near Middleton, Dawgreen, and Thornhill, overlies the Flockton Bed.

"The places where I have observed the working of the Flockton Bed, are Middleton, Adwalton, Cleckheaton, Dewsbury, Overton, and Flockton. The upper part, or roof of this bed, which contains the remains of fishes, is generally called *Stone Coal*, and is what Mr. Embleton has denominated at Middleton *Fish Coal*. The roof of the Stanley Shale Bed is exceedingly similar, and indicates a similar mode of formation.

"My attention having been directed to the fishes of the Yorkshire Coal Strata, by a fine collection presented to the Museum by Mr. Embleton, I commenced examining some dark shale brought out in sinking a shaft at Stanley, when to my no small surprise and delight, I found that it not only contained detached teeth and scales of fishes, but also numerous *Coprolites*, in the highest state of preservation. Finding these so interesting, I collected a great number of specimens at this locality, and also diligently examined the same shale at Newton Lane-end, at Grove Colliery, and at Westgate Common, at all which places I obtained abundant specimens.

"The shale containing these remains forms the roof of the Stanley Shale Coal, and is at Stanley six or eight inches in thickness: from the bed of coal upon which it rests upwards it passes into dark bind, which here contains numerous dispersed remains of molluscous animals, and nodular masses of iron-stone, rich in a small species of unio. This bind, when exposed to the atmosphere for a short time, becomes shivery, and the shells are liberated from the matrix. The shale itself

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resists longer this action of the atmosphere, but upon a long exposure, splits into thin plates; when newly brought out of the pit, it exhibits an exceedingly fine and homogeneous texture, and splits with a conchoidal fracture. The organic remains are not confined to any particular portion of the shale, but are indiscriminately disseminated through the whole stratum, the Coprolites being by far the most numerous. The shale is highly bituminous, and would, in many parts of the country, be regarded as a valuable article for fuel. It is soft and smooth to the touch, and slightly soils the fingers. When burning, it makes a crackling noise, gives out flame and smoke in abundance, and leaves a great deal of exceedingly fine, soft, white ashes. Some slight traces of lepidodendra may occasionally be detected in this shale, and a thin bituminous film, of a brilliant lustre, may in some places be observed, which seems to have had its origin in decomposed vegetable matter. This shale is entirely destitute of all remains of molluscous or entomostracous animals. The shale at Newton Lane-end, about a mile from the former locality, is very similar to that observed at Stanley, but it is of a coarser texture, which arises from a large quantity of sulphur disseminated in minute specks through the mass, coating with a bright golden hue the teeth and scales of fishes, or spreading in flowers near the Coprolites. Here, as at Stanley, the teeth and scales are detached, and after carefully examining a great deal of shale, I have scarcely in any instance met with any thing like the outline of a fish. In some places small assemblages of teeth, scales, and other parts of fishes, may be observed mingled together in confusion.

"The shale at Grove Colliery is very similar to that at Stanley; and a fragment presented to the Museum by Mr. Briggs, from Whitwood Colliery, two miles East of Stanley, is also similar. The shale at Westgate Common contains, besides the remains of fishes, some exceedingly sharp specimens of a small lepidodendron.

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"The *Flockton Stone, or Fish Coal*, is still more bituminous than the last; it is often used in the manufacture of gas; but when burned, it leaves a large quantity of fine, soft, brown ashes: a resinous substance, called middletonite, is found in it, which is supposed to be of vegetable origin. The remains of fishes in this bed, as in the Stanley shale, are disseminated throughout the entire mass, but certain layers may be observed in which they are more abundant. The parts are, as in the former shale, all detached, and blended together in confusion. Coprolites also are found in the Fish Coal, but they are by no means so well preserved as in the Stanley bed; indeed, they appear to have fallen upon a harder ground, and to have suffered from the action of the waters in which they were deposited.

"The thickness of the bed may be said to be about six or eight inches, the upper portion of it containing also layers of compressed shells. There appears to be little or no difference between the specimens from Overton and those from Middleton. At Dewsbury, the compressed shells occur in the whole mass, but I did not observe any remains of fishes; indeed the remains of fishes seem to be confined, in a great measure, to certain localities; for whilst they are abundant at Sir John Kaye's pit, at Overton, none could be found at the pit of Messrs. Stansfeld and Briggs, although only about a mile distant from the former.

"What may be the range and extent of these beds much South of Wakefield, I am unable to say; but I suppose the Stanley beds are wrought at a pit beyond New Miller Dam, on the Wakefield and Barnsley road; and I strongly suspect that the Stone or Fish Coal of Yorkshire is identical with the Cannel Coal of Wigan and Lancashire.

"These two beds, so rich in organic remains, fragmentary though they be, must be highly important and interesting to the naturalist and to the systematic geologist; but I beg

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respectfully to recommend them to the consideration of the practical miner, as strong and important lines of demarcation in the Yorkshire Coal Strata. The remains of fishes of the same species do indeed occur in the roofs of several other beds, so that they alone are not sufficient to identify the two beds which have been the subject of our present remarks; but these taken in connexion with the mineralogical character of the beds in which they are found, the peculiar manner in which they are imbedded, and taking into account all other available evidence, they can scarcely be mistaken for any other beds which occur in the Yorkshire series.

"But if we may regard these two beds as in reality beds of coal, their investigation will throw considerable light upon the question regarding the origin of that most valuable mineral. Every one who examines either of these beds will be convinced that it has been deposited in a state of very fine mud, and consequently under circumstances of great tranquillity. The scattered teeth and scales are all laid as they would be, if left to their own gravity, when sinking into a soft and yielding substance. This tranquillity is still more remarkably indicated by the high state of preservation in which we find the Coprolites. In general we may suppose that these frail substances, when first deposited, had become immediately enveloped with the soft mud into which they had fallen, and that they had never been disturbed until this substance had hardened around them.

"But whilst we have these evidences of the extreme tranquillity of the waters beneath which these beds had been formed, it is surprising that the teeth, scales, and other parts of fishes are all detached and fragmentary. In the Magnesian Limestone, the Lias, the Oölite, and in other formations, it is very common to meet with whole fishes, but in these two beds of the Coal formation we find the very reverse.

"Some of the Coprolites might possibly have been preserved

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for a considerable time in the bowels of the fish, but this could scarcely be a general case. I know it has been argued that the softer parts of fishes have been devoured by entomostraca, so abundant in some beds of the Coal Series, and thus the harder parts have been loosened, and carried away and dispersed by currents of water; but I have not been able to detect any such remains in the Stanley bed.

"But if these beds be indeed coal, and if they have been formed in the manner now represented, there arise the following interesting inquiries:—Whence had the carbonaceous and bituminous matter, of which they are chiefly composed, their origin? Did they consist of decomposed vegetable matter, which had been floating in the water and gradually subsided to the bottom? And are we to consider all coal as formed in the same way?

"It has been said that the vegetable structure has been observed in Coal itself; and nothing is more common than to find, in the Haigh Moor Coal, very perfect flutings and leaf-scars of sigillaria; but *where* these occur, the coal is of an inferior quality; and *where* the undecomposed flattened stems of sigillaria are very abundant, the substance formed is denominated "dirt," and is excluded from good saleable coal. With respect to the two beds of coal, upon which these remarks have been made, I think we may arrive at a negative conclusion,—viz. That the two beds of coal in question have not been formed of wood or vegetables piled upon each other, but by the gradual deposition of bituminous, carbonaceous, and earthy substances.

"There is no geological formation of so much economical importance, none requiring more minute investigation, and we may add, none more difficult of access to the ordinary observer, than the Coal formation. It is to gentlemen particularly engaged in mining operations, that we must look for information on matters connected with the important Coal-field of Yorkshire.

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" But whilst we thus submit to patient investigation in our own Coal-field, let us still take large and comprehensive views of the operations of nature. Let us not only consider our Coal-field in connexion with that of Lancashire, or Derbyshire, or Durham, but as forming a part of the great Coal-field of Europe. By thus combining theory with practice, the subject may not only yield economical benefit, but afford also intellectual gratification. That the various Coal-fields of Europe are all parts of one great contemporaneous deposit, is, I believe, allowed by all geologists; and that the carboniferous strata are but the poor remains of still more extensive deposits, which have been carried away by the denuding action of water, is a fact substantiated by the strongest evidence. It is unnecessary, however, here to enter upon any lengthened remarks on the denudation of strata. I may merely mention the Coal-field of Ingleton, which can be looked upon in no other light than a continuation of that of Bradford and Halifax; and it is well known that the two imperfect coal beds of the Eastern Moorlands of Yorkshire, which terminate at the vale of Cleveland, are found again in all their characteristic features in the northern parts of Scotland.

" Viewing the subject in this comprehensive manner, we may speculate on the nature of those extensive agents which have brought about the formation of our own Coal beds, and many facts may be brought to bear upon the perplexing question—Whether coal be formed of vegetable matter grown upon the spot where we find it, or, has that vegetable matter been transported from a distance?

" As it regards the Stanley shale, there can be no doubt that it has been formed beneath somewhat deep and tranquil waters, and that it has been deposited in the ordinary manner in which all shales have been formed. But in strata immediately above, we find the stems of sigillaria standing erect, as if in the very place where they had grown; and numerous

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instances of this kind occur in every Coal-field. The sandstones which generally enclose these remains with their accustomed irregularity, are strong marks of an agitated surface. How, then, can we account for appearances so dissimilar?

"For my own part, I look upon the Coal-field of Europe as the delta of some great and overflowing river; some ancient Nile, stretching its mighty arms into tropical regions: at one time an extensive plain of the most luxuriant vegetation,—at another time a sea of waters. But I hasten to conclude, lest I should waste that time in hypothesis which may be better spent in practical observation."

With this humble, but philosophic remark, Mr. Simpson terminates his communication; and I am sure it would be as unwise in me, as it would be unprofitable to you, were I in continuation to allow my imagination to run, as it might wish, into the mazes of vague hypothesis. The question so often agitated by the master minds of our science, is yet unanswered. Facts apparently most contradictory meet us at almost every step we take in the same Coal-field, but especially is it so when we pass from one Coal-field into another. Of this the Halifax Coal-field affords an instance. In it there have not as yet been discovered any of those Coprolitic remains which characterize the Wakefield series; nevertheless, we are led from its examination to similar conclusions with respect to the former existence of periods of repose and periods of agitation, as Mr. Simpson alludes to in his Paper just read. At one time we find the crushed and broken up fragmentary remains of large arborescent trees; at another time we meet with the most delicate forms of vegetable life, almost as unruffled as if they had but yesterday been placed between the leaves of a botanist's herbarium.

But further, with regard to alternation of deposition, we

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find in the Halifax formation, as complete a change from marine to fresh water fossils in the same pit, as could possibly be presented to us. At one time we discover a conglomeration of marine remains, as of Goniatites, Nautili, Orthoceræ, Pectens, and perhaps Belemnites, whilst a little lower down in the same series, we come upon a whole stratum of fresh water muscles, and these in such a perfect state of preservation, as to lead us to the inference that they were there embedded during a period of considerable tranquillity.

The discovery of these unios superimposing the lower, or soft bed, and the well known position of the marine animal remains in those singular concretions, called by the miners "Baum pots," immediately *above* the hard bed of coal, which is five and twenty yards above the former bed;—the abundance of sulphur and iron in combination in the nodules, popularly known by the name of "Brass lumps," interspersed largely throughout the seam of hard-bed coal, which is 2 ft. 3 in. in thickness, and the total absence of those in the foot and a half coal, or soft bed;—the cessation of marine animal remains after passing in descent through the hard bed, the change to vegetable impressions alone, and then the extraordinary fact of a stratum of unios lying beneath all these upon the soft bed;—and lastly, the almost non-fossiliferous nature of the coarse gritty sandstone upon which this last bed of coal rests, and, one might add, the total absence of fossils in the lowest sandstone, or millstone grit, which separates the next and last seam of coal, near Keighley, from the limestone shale;—these, I repeat, are facts which require much consideration, but which will doubtless eventually tend to throw considerable light upon this ancient formation; and I hope, at some future day, to be able to lay before you some more lengthened remarks upon these interesting beds of coal at Halifax.

In the meantime, permit me to remind you that the forma-

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tion of the various beds of coal, with their accompanying beds of sandstone and shale, present many difficulties which at present have had no satisfactory explanation, and it is perhaps only by numerous minute and accurate observations that the truth can be fully ascertained.

That many individuals engaged in mining operations possess much valuable information respecting the Coal Strata of Yorkshire, there can be little doubt; but with the exception of two or three short, but valuable essays, in the Transactions of this Society, and some observations in the *Encyclopædia Metropolitana*, I know of no other published account of the extensive and valuable Coal Formation of Yorkshire. Under such a state of our knowledge, a series of short observations from various localities, drawn up according to some stated formula, and printed in the Transactions of this Society, would be of the highest value.

Mr. Briggs exhibited and explained that portion of the line of section, comprehending the township of Thornhill and the hamlet of Netherton.

Mr. Holt exhibited and explained that portion of the line of section, comprehending the townships of Clifton and Hartishead.

Dr. Inglis exhibited two specimens of Nautili from the Halifax coal strata.

The thanks of the Society were then voted to the following gentlemen for their donations to the Museum, viz.;—

J. Ingham, Esq., for a Collection of Coal Fossils, Calamites, Sigillaria, Stigmaria, Fruits, &c.

W. Bean, Esq., Scarborough, a Collection of Oölitic Fossils; twenty specimens.

Mr. M. Simpson, remains of an Icthyosaurus and other Lias Fossils.

The thanks of the meeting were then voted to the Chairman for his able conduct.

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N. B. Dr. Inglis subsequently addressed the following letter to the Secretary :—

Halifax, March, 1844.

My dear Sir,—I regret that, from various causes, I shall not be able to attend the meeting at Sheffield, on Wednesday next, but in my absence, may I request you to present to the Society, for the next number of Transactions, the accompanying lithographs, which I have had taken from an interesting fossil nautilus, found in the shale of the upper of our Halifax Coal beds, and of which I spoke at the Huddersfield meeting.

I have sent, also, the fossil itself, that it may be compared with the lithograph, and shall feel obliged by your taking care of the fossil, as it is the property of the Halifax Literary and Philosophical Society, after whose late president and founder I beg to name it.

The characteristic features of the fossil may be enumerated as follows :—

N. Rawsoni.—Discoid, shell thick and smooth; aperture, trapezoidal, being widest at its inner margin; volutions, four or five, exposed; outer whorl, not half the diameter of the shell; umbilicus large; striæ undulating, bend from the aperture on the back; sides with a deep, wide, concave channel, near the outer margin; edges rounded; back with a broad, flat groove in the middle, a smaller one running on either side of this.

The siphuncle is very near the back, as in the Ammonite, but the fossil has the characteristic septa of the Nautilus.

It was taken from the Catherine Slack Coal Beds, which lie on the Halifax and Bradford old road, about a mile and a half north of Halifax, (proprietor, Joseph Stocks, Esquire.) The figures A C B give a good view of the deep whorls, the umbilicus, the grooves upon the back, and the aperture of the shell; and the figures of the fragments C and D exhibit the septa and the dorsal siphuncle.

The specimens here represented are the only fossils of this species hitherto discovered in this neighbourhood, and I am not aware of their having been described elsewhere.

J. T. Clay, Esq., Rastrick. JAMES INGLIS.

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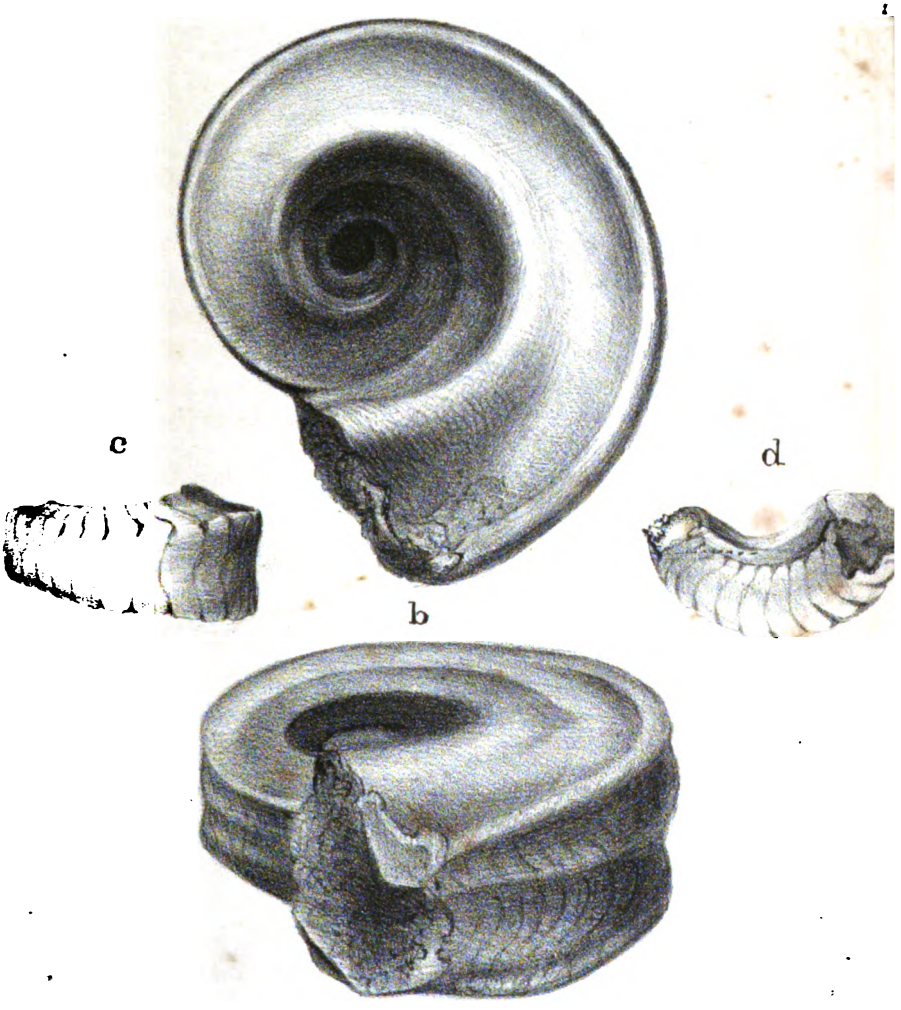

T. Physick lith.

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE TWENTY-FIFTH QUARTERLY MEETING, HELD IN THE CUTLERS' HALL, SHEFFIELD, ON WEDNESDAY, THE 6TH OF MARCH, 1844.

On the motion of HENRY BRIGGS, Esq., seconded by WM. LUCAS, Esq.,

GEORGE C. HOLLAND, Esq., M.D., was called to the Chair.

The following minutes of the meetings of the joint Committees of the West Riding Geological and Polytechnic Society and the Leeds Philosophical and Literary Society were read:—

"At a Meeting of the joint Sub-Committees of the Leeds Philosophical and Literary Society, and the West Riding Geological and Polytechnic Society, held in the Philosophical Hall, Leeds, March 4th, 1844;

Present,—J. G. MARSHALL, Esq., in the Chair;

Messrs. Briggs, West, Wilson, Clay, Nunneley, Ward, and T. P. Teale.

"The minutes of former meetings were read, and the rooms having been inspected,

"IT WAS RESOLVED,—'That the room now occupied as the Antiquities Room be appropriated for the Museum of the Geological and Polytechnic Society, except that the mummy shall remain in its present situation.

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"'That, in order to meet the outlay attendant upon the removal of the specimens from the Antiquities Room, and providing suitable accommodation for them elsewhere, the Geological and Polytechnic Society shall contribute the sum of fifteen pounds towards the expense.

"'That, in order to diminish such expenses, a temporary interchange of such cases as may be suitable is advised.'"

It was moved by Mr. WILSON, and seconded by Mr. WALLEN, and resolved unanimously,—"That they be confirmed."

On the motion of the SECRETARY, Mr. JOSHUA KAYE, of Huddersfield, was elected a Member of the Society.

Mr. CHARLESWORTH proposed, and Mr. BRIGGS seconded, a vote of "Thanks to the Master Cutler for the use of the Hall."

Mr. CHAMBERS proposed, and Mr. MORTON seconded, a vote of "Thanks to the Literary and Philosophical Society of Sheffield, for their assistance in making arrangements for the Meeting."

Mr. WALLEN then read a paper entitled "An Investigation of the Theories as to the origin of Gothic or Pointed Architecture." (The author declines to publish this paper.)

Mr. LUCAS then proceeded to read a paper on spontaneous decomposition of fat, as exemplified in the remains of candles found in mines that have long been abandoned. He produced several small pieces of white matter, furnished to him by Mr. Lee, which, though appearing now only as white chalky substances, were believed to be the remains of candles, which had been left for many years in the mines where they were found. He showed that the substances burned easily. He then proceeded to state the discoveries of a French chemist, as to the component parts of fat, and also referred to the facts brought forward by Mr. Beetz, at a meeting of the Chemical Society of London, on the subject

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of similar relics to those he now produced. He then went on to show that the specimens he produced, when tested by various experiments, were found to correspond with Mr. Beetz's experiments, so far as he (Mr. Lucas) had had the opportunity to carry them. Two of the pieces were found in an old mine near Eyam, where they were believed to have been from 40 to 50 years. Another piece, however, was changed almost completely to the appearance of chalk, and it was found in a mine where it must have been for 150 years. All appearance of a wick had disappeared in the latter piece. Remnants of candles from the wreck of the *Royal George* had a mineralised appearance, and had no remains of wick. Mr. Lucas concluded by explaining the theory of the change, which he compared to the discovery of dead bodies found in the state of adiposea.

Mr. BIRAM confirmed the statement as to the similarity of those fragments to a portion of candle from the wreck of the *Royal George*, which was in his possession.

The CHAIRMAN thought it probable that the wick in the more completely changed portion was decayed.

Mr. MORTON was inclined to think that the vegetable wick, if it were decayed, must have left a mark of carbon. He proceeded to remark on the fact incidentally noticed by Mr. Lucas, that butter made in summer contained the greater proportion of oleine, and in winter of stearine. This he traced, not to the change of atmosphere, but of the food of the animals. He inferred, from the analysis detailed by Mr. Lucas, that the stearine candles, in which the oleine was removed, were very superior.

Mr. LUCAS, in reference to the feeding of cows, referred to the statement of Professor Playfair, that the milk of cows grazed out of doors contained casine, the principle of cheese, but was not of equal advantage for butter. The milk of cows fed in the house did not so well produce cheese.

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In answer to Mr. Briggs,

Mr. Lucas said, that these old candles were found in lead mines; and

Mr. Briggs inferred that they must have been exposed to lime water.

After a little further conversation, a vote of thanks was passed to Mr. Lucas, and another to the Chairman, and the Meeting adjourned to the Evening Sitting.

At the Evening Sitting, a paper was read

ON THE FOSSIL TREES FOUND STANDING UPRIGHT IN THE COAL MEASURES. BY E. W. BINNEY, ESQ.

In this paper, which was long, and illustrated by numerous drawings, the author gave descriptions of many fossil trees found in erect positions in different parts of the carboniferous strata, but chiefly in the "roofs," (the beds immediately above the seam of coal,) nearly all of which he referred to the genus Sigillaria. His specimens were for the most part from the Lancashire Coal-field, although he stated that they were also to be found in most other fields, and were well known to miners under the name of "*Pot-holes.*"

He then alluded to the Dixon Fold Trees, found in cutting the Manchester and Bolton Railway, so well described by the late Mr. Bowman, and brought forward by that able Geologist as positive proofs that the vegetable matter, forming the beds of Coal upon which they stood, had grown upon the spot were it was now found. (See vol. 1, p. 112, of the Transactions of the Manchester Geological Society.)

He next fully described the singular genus of hitherto supposed Coal plants, Stigmaria, and stated that he had found evidence of that fossil in the floors (the strata on which the coals rest) in all the seams examined by him in the Lancashire Coal-field, amounting to near 100 in number.

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The fossil trees found in a quarry at St. Helen's were then described, as exhibiting the stems of Sigillaria absolutely united to the roots of Stigmaria, thus first proving the identity of these two hitherto supposed different plants. (See Philosophical Magazine and Transactions, 1844 and 1845.)

And the author came to the following conclusions, namely:—That plants of the genus Sigillaria were the chief constituents of such beds of Coal as those in which Stigmaria was found in the floors. That such vegetable matter had undoubtedly been grown on the spots where it is now found, and not drifted from a distance. And lastly, that each seam of Coal indicated a period of repose of the earth's crust, during which a separate marine forest of vegetation grew, in the successive subsidences of the area on which the Coal Measures were formed; the sandy, silty, and argillaceous strata known as Coal Measures, having been caused chiefly by currents of water produced by subsidences of the earth's crust, whilst the Coal Seams themselves were formed from plants grown during the periods of repose of such crust.

Mr. Biram exhibited and explained the construction of an improved Anemometer.

The Secretary read a communication from Dr. Inglis, explanatory of an engraving of a Fossil Nautilus, found near Halifax, which he presented to the Society, and which was inserted in the last number of the Transactions.

Thanks to the Authors of the papers, and to Mr. Biram and Dr. Inglis, were voted.

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE TWENTY-SIXTH QUARTERLY MEETING, HELD IN THE HALL OF THE PHILOSOPHICAL AND LITERARY SOCIETY, IN LEEDS, ON WEDNESDAY, THE 10TH OF JULY, 1844.

On the motion of JAMES GARTH MARSHALL, Esq., F.G.S., seconded by the Rev. WM. THORP,

The Chair was taken by WILLIAM WEST, Esq., Vice-President.

The SECRETARY moved, and Mr. THOMAS WILSON seconded, the election of Mr. THOMAS WALKER, Leeds Borough Surveyor, as a Member of the Society.

Mr. HARTOP moved, and the Rev. WILLIAM THORP seconded, a resolution "That the thanks of the Society be given to the Philosophical and Literary Society for the use of their Hall at this time."

The Rev. WM. THORP read a paper "Describing some of the Principal Faults in the Yorkshire Coal Field." This paper will be printed in the forthcoming volume "On the Geology of the Yorkshire Coal Field," by the above gentleman.

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The following letter from Mr. Barker, of Whitehaven, regarding the performance of one of Mr. Fourness's Machines for Ventilating Coal Pits, &c., was read:—

Whitehaven, May 22nd, 1844.

MR. WILLIAM FOURNESS.—SIR,—Your machine for ventilating mines having been in operation upon my new winning, at Wyndham Colliery, near this town, a sufficient length of time to test its efficiency, I have to make the following statement of its results:—The mine, before the machine was applied, was ventilated by a furnace consuming 45 cwt. of small coal in 24 hours, exhausting 5,700 cubic feet of air per minute. Since the machine has been applied, our ventilation is more than doubled, and, as the machine throws off 13,500 cubic feet per minute, it is our fault if we do not secure that quantity of air through the mine. The machine is driven by power taken from our pumping engine, and, by careful experiment, I have found the additional consumption of small coal to be 9 cwt. per 12 hours. This, therefore, is all the cost of working the machine. I have to add, that I am gratified with the performance of the machine in every respect. The Colliery kept me in continual fear of an accident before erecting the machine; whereas the ventilation is so much improved, we now work without danger, and I am happy to bear this testimony in its favor.

I remain, Sir, &c.,

RICHARD BARKER.

At a preceding Meeting of the Society, Mr. HARTOP read a communication from Mr. FOURNESS, describing the construction of the above machine, (for which a patent was obtained November 16th, 1837,) together with some remarks "On the Advantages of Mechanical Force over the Power of Rarefaction in Ventilating Mines and Buildings," as exhibited by the efficiency of his apparatus, of which paper the following is an abstract:—

"The machine applied at the Wyndham Colliery consists of a drum made of sheet iron, one-eighth of an inch in thickness; the dimensions are five feet diameter, and 27 inches

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broad; the inlets or passages for air are exactly one-third of its diameter; the interior of the drum contains six fanes, extending from the extreme diameter of the inlet to the outer circumference of the drum; one-third of the space between each fane is left open for the delivery of air; the remaining two-thirds are closed by a plate, called a vacuum plate, which prevents the atmosphere from lodging behind the fane. This machine performs 230 revolutions per minute, is fixed over a Staple Pit, which is connected with the Back Pit or Engine Pit, and throws off exactly the same number of cubic feet at every revolution, which the drum contains. The inlets at the sides consist of a cast iron rim turned true on the face, revolving against a fast face of iron, also turned true, and screwed to a wood pipe, which I find answers well to be in breadth two-thirds the length, consequently in the form of a parallelogram; the depth of this pipe is discretionary, as circumstances require; I recommend six feet. The top of the pipe lifts off, to admit the drum and the shaft into their proper place; the plummer-blocks and brasses are outside of the pipes, and level with the parting in them. By constructing a machine as above you need no case, and avoid all clearances between the fan and the case,—a very great evil in the common fan. This machine runs without noise."

The Author's attention was first called to the subject by the Report from the Select Committee of the House of Commons "*On Accidents in Mines*," which recommended greater care and caution to be used by all grades of individuals engaged in mining operations, and that nothing could be done which could be more effectual than the plans they had brought before them; and that with proper and careful use of the Safety Lamp, the painful calamities they had to investigate would, to a great extent, be avoided. Mr. Fourness, however, was of opinion that to prevent

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explosions from carburetted hydrogen gas (fire-damp) in mines altogether, the most efficient remedy would be to obtain a more powerful ventilation in the place of the old plan of using a furnace, or cupola, by causing a larger current of air to pass through the workings, so that the whole of the atmosphere should be sufficiently diluted below the "*Firing Point*," and thus the materials for combustion and explosion would be removed or rendered harmless, and no accidents occur from that cause. With this view he constructed a model of a machine to effect so desirable an object, in October, 1835. Having succeeded thus far, he says "My next business was to look out for a well which was surcharged with carbonic acid gas; I found one in Balloon Street, Brewery Field, Leeds. I applied it to this well, which was 27 yards deep, and four feet six inches in diameter. The model cleared this well, which was at the commencement entirely filled with foul air, in 25 minutes. A few weeks afterwards, being in the immediate neighbourhood, I was called upon to attend without loss of time, as there were two men suffocating in the well. When I arrived, I found this correct, and set the machine to work; the men almost immediately recovered, and without any other assistance came out of the well. The master well-sinker said it was certainly a most capital invention, but that the well-sinkers could not encourage it. I asked him his reason, 'Well,' he replied, 'you have deprived me of the profits of my men's wages for one day, which time it would have taken to fix the bellows.'" This model was twelve inches in diameter by five inches broad, and could be carried on the shoulder to any part of the town, and applied to a well in one minute. Subsequently, in November, 1837, a machine of larger dimensions, five feet in diameter by two feet broad, was constructed and applied to a pit at Osmondthorpe Colliery, near Leeds, in connexion with

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which was a *Water-level*, which had been set on fire about 18 months previously by an explosion of carburetted hydrogen gas. "This place was immediately cleared of all the smoke, sulphur, &c., which could not be moved by the power of the cupola;" thus affording additional evidence of the superiority of Mechanical Force over the power of Rarefaction in promoting Ventilation, an increase of which, as the Author observes, would invigorate the pitmen, and enable them to go through their labour with greater comfort; in many cases with improved health; and the general working of the mine be greatly facilitated. "The present velocity with which wind travels through mines is at the rate of from three to four feet per second. This velocity suits the Safety Lamp, inasmuch as a wind travelling at a greater speed in a highly explosive medium, would cause the flame to pass the gauze of the lamp, and explode the mine. But were the current of air to be increased to double that velocity, there would be no necessity for the Safety Lamp at all."

In discussing the relative consumption of fuel, and the results to be obtained by his method of Ventilation and that of the plan in general use, Mr. Fourness gives the following calculations in support of his invention being more economical and efficient.

"I may here state how much fuel would be required for a furnace, either at the top or bottom of the shaft, to exhaust 10,180 cubic feet of air per minute. The answer is 46 cwt. of good coal in 24 hours, or rather better than 4½ lbs. of coal per minute; according to the rules for ascertaining the quantity of fuel required for an ordinary mine, say the depth of upcast 200 yards, as the length of shaft is not of so great importance for ventilation, when reaching above 60 or 70 yards; making a difference of 2½ lbs. of coal per minute, or 36 cwt. per 24 hours, for it appears plain that 10 cwt. of good coal, (where mechanical

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force is used,) will cause as good a ventilation as 46 cwt. will do when consumed at a furnace. I take the above 200 yards as the average depth of mines generally.

"I might here observe, that where a fire is used in the bottom of a shaft, the temperature in the upcast decreases as the square of the distance from the fire. Therefore, I should not say that a deep mine is more difficult to ventilate than one of 60 or 70 yards. Suppose a furnace consumes 18 cwt. of coal in 24 hours, and exhausts 212 cubic yards of air per minute, if I wish to ascertain how much fuel it would require to exhaust double the quantity of air in the same given time? The following rule will give the answer:—The required quantity being 424, it must be cubed and multiplied by 18, the quantity of fuel known for 212 cubic yards. The product of the larger number must be divided by the lesser, which gives a quotient of 144; when divided by 2, the square of the increased quantity equals 72 cwt. for 24 hours. If we are desirous of knowing how much air 80 cwt. of good coal will cause to pass through a mine per minute, half the square root of 80 gives the answer, allowing the two first decimals in the root to be primes; the quotient is 447 cubic yards of air per minute. This question may also be answered thus:—Suppose air travels at the rate of five miles per hour through the workings of a mine, every object this air comes in contact with, it strikes with a given force equal to 0.123 of a pound on the square foot; but if caused to travel ten miles per hour, it will strike with four times the force, viz., 0.492 of a pound on the square foot. Therefore, if wind is required to travel at double the velocity through mines, there must be four times the quantity of fuel used to produce the force above specified. Allowing these observations to be correct, many evils would arise from the use of such extensive fires, such as destruction of the sides of the *upcast shaft*, *ropes*, *guide rods*, and, indeed, all substances that come within the limits of its power.

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"The dimensions of an ordinary furnace are 7 feet long and 5 feet wide on the grate bars. If four times the fuel were required to be consumed in the same time, (as is generally used,) the grate bars must be four times the area, that is, 14 feet long, by 10 feet broad. I am of opinion a greater evil would arise from the use of this furnace than what is generally anticipated. Bicarburetted hydrogen, or what is commonly termed 'fire damp,' reaches the explosive point at a temperature of 500° or 550° Fahrenheit; and having a surface of fire equal to double the length to pass over, must reach to a sufficient temperature for combination, and will instantly take fire."

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE SIXTH ANNUAL MEETING, HELD IN THE HALL OF THE MECHANICS' INSTITUTE, AT WAKEFIELD, ON WEDNESDAY, THE 18TH DECEMBER, 1844.

HENRY BRIGGS, Esq., was called to the Chair, and opened the meeting with a few very appropriate remarks, in which he expressed an earnest hope that the public might by some means be induced to take more interest in the proceedings of this Society. He feared some misapprehension existed as to the objects and nature of the Society. It was not only a Geological one, but also Polytechnic. This was a comprehensive title—anything useful to mankind, every improvement in machinery, manufactures, and agriculture. Now that such a spirit exists for railroads, nothing better could be in existence than a Society of this kind, to render the transit of passengers and goods as safe as possible. A little more exertion on the part of the members might widen the sphere of the Society considerably. He (the Chairman) hoped to see greater interest manifested in the proceedings. Many members might imagine that it was very difficult to produce a paper to read at the meetings. He (the Chairman) never promised to produce a paper, for he was always at a loss how to commence; but when he once sat down, he then could

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proceed onward without difficulty; one thought begot another, and it was almost as difficult to stop. Discussions were always, in his opinion, advantageous; and, by the production of a moderately written paper, a discussion might be produced which would benefit every one present. He hoped to see the Society rise again with greater vigour, and be a honour to the county.

Mr. CLAY, the Honorary Secretary, read the following Report of the Proceedings of the Society for the past year:—

REPORT OF THE COUNCIL OF THE GEOLOGICAL AND POLYTECHNIC SOCIETY OF THE WEST-RIDING OF YORKSHIRE, PRESENTED AT THE SIXTH ANNUAL MEETING, ON THE 18TH OF DECEMBER, 1844.

In rendering to the Members of the Geological and Polytechnic Society a statement of the proceedings of the past year, the Council have to report that the Quarterly Meetings, with one exception, have been held with regularity, and that many valuable communications have been made,—some, illustrations of the particular Geology of the county, and others embracing subjects of more general application.

The following Papers have been read:—

At the Annual Meeting in Wakefield, SEPTEMBER, 1843—

"On a remarkable case of the action of Spring Water on Lead," by William West, Esq., of Leeds.

"On the action of the Atmospheric Railway, between Kingston and Dalkey," by William Lucas, Esq., of Sheffield.

"On Ventilation," by Henry Hartop, Esq.

At the Meeting at Huddersfield, DECEMBER 6th, 1843—

"Observations on the Discovery of Coprolites in the Stanley Shale and Flockton Stone, or Fish Coal," by Mr. M. Simpson, of Whitby.

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"Description of a New Species of Nautilus (N. Rawsoni) from the Halifax Coal Field," by Dr. Inglis.

"On Industrial Farms and Cottage Allotments," by J. Nowell, Esq., of Farnley Tyas.*

At the Meeting in Sheffield, MARCH 6th, 1844—

"An Investigation of the Theories as to the Origin of Gothic or Pointed Architecture," by William Wallen, Esq., F.S.A.

"On the Fossil Trees found standing upright in the Coal Measures," by E. W. Binney, Esq.

"On the Spontaneous Decomposition of Fat, as exemplified in the Remains of Candles found in Mines that have long been abandoned," by Wm. Lucas, Esq., of Sheffield.

At the Meeting in Leeds, JULY, 1844—

"On some of the Principal Faults in the Yorkshire Coal Field," by the Rev. Wm. Thorp.

A Letter from Mr. Barker, of Whitehaven, regarding the Efficiency of Mr. Fourness's Ventilating Machine.

In addition to the following Papers, several portions of the Line of Section have been presented to the Meeting by W. S. Hall, H. Hall, and H. Briggs, Esqrs. The Council regret that they cannot report the final completion of this undertaking; but as only a small portion remains unexecuted, it is expected that the next Report will announce the termination of the labours of this Committee.

In reviewing the names of the contributors of Papers, it is obvious that the labourers are few in comparison with the number of Members whose talents and acquirements would render their assistance highly desirable; and if others who possess ample means for increasing the efficiency of the Society, would make the results of their observations known

* This Essay has since been printed and passed through two editions.

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through the medium of our Meetings, the scientific investigation of this district, which is second in importance to none in the kingdom, would be greatly advanced. The probability of this county becoming the scene of extensive railway operation, renders the proceedings of the Society for some years of great interest. Such a favourable opportunity for examining the structure of this district may probably never again occur; and if the facilities which will be afforded be properly cultivated, a mass of information of the greatest practical importance may be collected. The Council especially recommend this subject to the attention of the Members generally, and more particularly of those gentlemen whose engagements render them familiar with the projected works.

In accordance with the notice laid on the table at the last Annual Meeting, the Council took the needful steps for carrying out the arrangements for the proposed removal of the Museum; and they have now to report that the specimens have been placed in a separate apartment in the Hall of the Philosophical and Literary Society of Leeds; and it is hoped that the opportunity of studying the peculiar fossils of our own coal field, in connection with the more general collection, to which our members have free access, will tend to the cultivation of Geological science, and increase the interest felt in this Society.

The British Association for the Advancement of Science having met at York at the period generally appointed for our anniversary, it was considered (after much deliberation, and with the full concurrence of the President) to be most expedient to postpone the Annual Meeting till this time. It will, therefore, be needful to proceed to the appointment of officers for the ensuing year, and to the consideration of the financial position of the Society.

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STATEMENT OF THE RECEIPTS AND EXPENDITURE,

From September 25th, 1843, to September 25th, 1844.

DR.	£.	s.	d.
Subscriptions—			
From 1 Member for 1839..	0	10	6
,, 2 ,, 1840..	1	1	0
,, 4 ,, 1841..	2	12	0
,, 73 ,, 1842..	47	9	0
,, 77 ,, 1843..	50	1	0
,, 4 ,, 1844..	2	12	0
	104	5	6
Balance due to Treasurer	16	3	10
	£120	9	4

CR.	£.	s.	d.
Balance due to Treasurer	2	14	1
Printing and Stationery	0	19	0
Expenses of Museum	10	12	2
Removal of Museum	15	7	6
Advertising Meetings	3	12	6
Rent, from Nov., 1843, to July, 1844, (one year and eight months)	25	0	0
Collecting Subscriptions	2	14	4
Postages	4	12	3
Expenses of Meetings	2	7	8
Printing Reports	51	10	0
	£120	9	4

The following gentlemen were then declared duly elected to be the Officers of the Society :—

President.

EARL FITZWILLIAM, F.R.S.

Vice-Presidents.

Duke of Norfolk.	T. W. Beaumont, Esq.
Earl of Effingham.	J. S. Stanhope, Esq.
Earl of Dartmouth.	R. O. Gascoigne, Esq.
Lord Wharncliffe.	G. Lane Fox, Esq.
Lord Stourton.	J. W. Childers, Esq. M.P.
Viscount Milton.	E. B. Beaumont, Esq.
Viscount Howard.	G. Wentworth, Esq.
Hon. W. S. Lascelles, M.P.	W. Bennett Martin, Esq.
Hon. J. S. Wortley, M.P.	C. J. Brandling, Esq.
Sir F. L. Wood, Bart.	J. G. Marshall, Esq.
Sir W. B. Cooke, Bart.	Michael Ellison, Esq.
Rev. Dr. Scoresby, F.R.S.	T. D. Bland, Jun., Esq.
Rev. S. Sharp.	P. D. Cooke, Esq.
Rev. T. Barnes.	Wm. West, Esq. F.R.S.

Council.

H. Briggs.	Charles Morton.	H. Holt.
W. T. Hall.	George Welch.	H. Clarkson.
H. Hartop.	Thomas Wilson.	J. Westmorland.
J. M. Stansfeld.	W. R. H. Johnstone.	Charles Locke.

Secretary and Treasurer.

Rev. William Thorp, Womersley Vicarage.

Honorary Curators.

T. W. Embleton and J. G. Marshall.

Auditors.

Benj. Biram and G. W. Chambers.

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The Rev. Wm. Thorp then read the following paper :—

ON THE CAUSES OF THE DIFFERENT RATES OF MORTALITY IN SOME OF THE MOST POPULOUS TOWNS IN THE WEST-RIDING OF YORKSHIRE.

It is highly probable that if any general diminution of human suffering is to be afforded to large portions of mankind, it will be in the prevention of those diseases which destroy great numbers of the human race.

As all classes of men have the same organization of their bodies, it might be expected that they would live, on an average, the same number of years; but as this is not the case, it becomes a most important subject of inquiry, to determine to what extent life is shortened under the more unfavourable conditions of climate, locality, employment, diet, &c.; and as the influence of these various circumstances can only be efficiently investigated upon the spot where they are found, it becomes worthy of the attention of a local society like ours, to examine the causes of the different rates of mortality in some of the most populous towns in the West-Riding.

Halifax and Huddersfield, both large manufacturing towns of the same staple article, and with a dense population of above 100,000 persons in each, (*i. e.* in the Registrar-General's districts), *have exactly the same rates of mortality.* That is, taking the population and the number of deaths in each district, and dividing the one by the other, the rate of mortality in each is 2.1 per cent. per annum, or 1 in 48 dying for the three years past, or as far as we have any authentic information from registration. These towns, moreover, are extremely healthy, being more so than any of the large towns in England, with the exception of Kidderminster. They are even more healthy than the rural

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districts of Doncaster and Thorne, and of Selby, Goole, and Pontefract. The *cause* why Halifax and Huddersfield possess *similar* degrees of healthiness is, that they are built upon the *same* Geological strata; and why they are so exceedingly healthy is, that they rest upon the millstone grit, which, as we shall see in the sequel, presents conditions highly favourable to longevity.

Leeds and Sheffield, both manufacturing towns of different staple commodities, the one of flax and woollens, the other of steel and iron,—the one containing twice the amount of population to the other, have likewise their rates of mortality or degrees of unhealthiness for the same three years exactly alike, viz., 2.7 per cent per annum, or 1 in every 38 persons dying. These two towns are, however, exceedingly unhealthy; and supposing their population to be equal to that of Huddersfield and Halifax, in every ten years 17,430 persons more, in proportion, would be destroyed by disease. The reason why the rates of mortality are alike in Leeds and Sheffield is, because they are built upon exactly the same strata, which are continuous from one place to the other; and why they are so extremely unhealthy is, because they are located upon "clays and binds" of the coal formation, which present certain conditions prejudicial to health.

The districts of Wakefield and Barnsley, in like manner, have degrees of healthiness or rates of mortality exactly alike, these being intermediate between those of Huddersfield and Halifax, and of Leeds and Sheffield. The towns of Wakefield and Barnsley are built upon the same rock of the coal strata, and which affords sanatory advantages differing from the before-named districts.

That the healthiness of any town depends directly or indirectly (cœteris paribus) upon its Geological site, is plain, since all the conditions necessary to health, as ventilation, drainage, the supply of water, pure air, &c., are dependant

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upon the same cause. Thus, indirectly, where good building-stone exists, the walls of houses are seldom made less than fifteen inches thick; and when thick walls are made, the rooms of the houses are made larger also, and are placed, if possible, in streets; and hence a better ventilation, more light, air, &c. A town built upon a rock possesses also a natural good drainage, arising from fissures and porosity of the substratum; there is also less of exhalation and of miasmata, and, therefore, a purer air. The water in such cases is generally not only purer but more plentiful. The millstone grit and mountain limestone regions, and of other coarse sandstones and of the oölites, are the most healthy districts; while those *of clay* are the most unhealthy; and here are seen small inferior houses—no attention to the size of rooms, houses, or streets, imperfect sewerage, malaria, and all its effects. The new red sandstone and magnesian limestone hold an intermediate station between the two, the former having a very imperfect, and in many places no building material except the marl seams; yet the new red sandstone has good natural drainage, while the limestone makes inferior houses, and the water upon it is scanty and not very pure. Thus Bradford, with a dense population, is more healthy than Leeds, having a rate of mortality of 1 in 43 dying annually, while in Leeds 1 in 38 die; and this because one-half of Bradford is built upon the flagstone rock, forty-five yards thick. Newcastle-upon-Tyne stands upon the *clays* of the coal measures, and has a rate of mortality higher than Leeds, viz., 1 in 34; but the millstone grit and mountain limestone districts of Glendale, Bellingham, and Haltwhistle, about fifteen miles west of Newcastle, are just *twice as healthy* as Newcastle, their rates being 1 in 68.

Hull, standing upon clay, and built of bricks made from it, has a rate so high as 1 in 34, being the same as Newcastle. Cambridge, for the same reason, is as high as 1 in 37.

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York, for the same, as high as 1 in 46. Liverpool, the most unhealthy town in England, has no building stone; hence 60,000 people live in cellars, and its rate is as high as 1 in 29. Manchester, chiefly for the same reason, although it has not the same amount of cellar population, is 1 in 33; and in Salford 1 in 36. The oölite regions of Easingwold, Helmsley, Pickering, Malton, &c., stand as low as 1 in 55, and are more healthy than Halifax and Huddersfield.

In these calculations it is to be remembered that under the very best sanatory regulations, in the most healthy locality, and with every wish gratified, a certain number of deaths from disease take place *at all ages*. It is a law of nature; and although, by ameliorating the health and by diminishing the sufferings of the people, this number has been and will be diminished,—yet the same law, with modifications, will ever exist. According to information we possess, the expectation of life is as follows:—

Suppose 100,000 children were born upon any day—

74,201	would be alive at	5	years old.
70,612	ditto	10	do.
68,627	ditto	15	do.
66,059	ditto	20	do.
60,332	ditto	30	do.
50,301	ditto	45	do.

Hence the probable duration of life in England is 45½ years, for it is the time in which the number born is reduced one-half. In Halley's words, it is "an even wager" that a child will live 45½ years.

37,996	would be alive at	60	years old.
24,531	ditto	70	do.
9,398	ditto	80	do.
1,140	ditto	90	do.
16	ditto	100	do.
1	ditto	105	do.

See Report of Registrar-General for 1843, p. 23.

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There is, therefore, a double inquiry. Why are the degrees of healthiness respectively of some of these towns so nearly alike, or, in fact, identical? and why again do those of others so remarkably differ? There must be, therefore, some general causes, independent of occupations, density of population, poverty of the district, &c., which exercise so material an influence over the duration of life; and it will be found that the different physical conditions of the inhabitants of each town, depending chiefly upon *Geological* influences, are such as either generate or make more fatal those peculiar diseases by which the excess of mortality is occasioned.

Before being able to show how the Geological site of these towns modifies the duration of the life of their inhabitants, and in order to derive all the advantages from the Registrar's Reports already published, it will be necessary to collect and compare the *population*, the number of *deaths*, and the peculiar *diseases* by which the mortality in each town is occasioned.

As Leeds and Sheffield have the same rates of mortality, the same Geological site, and occupy the extreme point of unhealthiness; while, on the other hand, Halifax and Huddersfield have a Geological locality identical with each other, but differing from Leeds and Sheffield, and are exceedingly healthy towns, the population, deaths, and diseases of the former towns must be compared with those of the latter towns.

There is, however, considerable difficulty in comparing the diseases and the deaths of Leeds and Sheffield with those of Halifax and Huddersfield, on account of the greater population of the two former towns; and there is left only the choice of making a proportion between the deaths and population of the one, and calculating for the others, or to add some smaller town whose population will bring Halifax and Huddersfield to a standard with Leeds and Sheffield. Both of these modes, however, have been adopted in the following Paper.

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The *population* of the poor-law districts of Halifax and Huddersfield is 216,315, while that of Leeds and Sheffield is 253,743; and by adding the district of Wakefield, with a population of 45,648, the population of Halifax, Huddersfield, and Wakefield amounts to 261,963, or 8,220 more persons than in Leeds and Sheffield; and consequently the comparison is greatly to the disadvantage of Halifax and Huddersfield, not only by this additional number of population, but its being added from the rather more unhealthy district of Wakefield.

The number of deaths in Leeds and Sheffield during the years 1841, 1840, 1839, and 1838, were 27,299; in Huddersfield and Halifax during the same years they were 17,331. Making allowance for the difference of population between the places, 1,743 more deaths occur annually in Leeds and Sheffield. Or by adding Wakefield, which makes 8,220 more people, there remain 1,398 more deaths; *i. e.* there are more deaths by 1,398 in Leeds and Sheffield than in Halifax, Huddersfield, and Wakefield, with 8,220 additional population.

Let us now examine by what particular diseases this extra mortality in Leeds and Sheffield is occasioned. The diseases of childhood claim the first attention. In Sheffield and Leeds very nearly *one-half of the deaths* are of children before the age of five years—the numbers in 1841 being 3,151 out of 6,582 deaths; in 1840, 3,306 out of 6,898 deaths. Again, in these towns one-half of those who die under five years do not attain the age of one year, the numbers being in 1841, 1,691 out of 3,151, (or 17 to 32 nearly); and in 1840, 1,736 to 3,306. In Halifax, Huddersfield, and Wakefield the number of deaths under five years of age are a little, but not very much, fewer in proportion, being in 1841, 2,312 out of 5,282 deaths, (23 to 53); and in 1840, 2,621 to 5,868 deaths, (26 to 58), and

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quite as many die in these latter places, in proportion, before attaining the age of one year.

The diseases by which this prodigious number of children are annually destroyed are chiefly convulsions, scarlatina, small-pox, hydrocephalus, teething, hooping-cough, measles, croup, tabes mesenterica, and worms. In the whole of these Yorkshire towns during the four years of 1841, 1840, 1839, and 1838, there died 15,005 children under five years of age, of these diseases. In Leeds and Sheffield, 8,640; and in Halifax, Huddersfield, and Wakefield, 6,365, leaving in favour of the three latter places 2,275, or about 570 per annum. There are also a small number destroyed by remittent fever, pneumonia, diarrhœa, and thrush, not included in the enumeration. During these four years, scarlatina was at least twice as fatal every year in Leeds and Sheffield as in the other three places; and in 1838, small-pox carried off in Leeds and Sheffield four times as many; while convulsions and hydrocephalus (water in the head) destroyed 6,880 (say 7,000) out of 15,000 during the same period, and these two latter diseases (convulsions and hydrocephalus) were quite as fatal in Huddersfield, Halifax, and Wakefield, as in Leeds and Sheffield. They are, no doubt, increased by the enormous quantity of soothing syrups and cordials, containing poisonous doses of opiates. In Ashton-under-Lyne, seven gallons per week are sold, under the names of "Godfrey," "Dalby," "Soothing Syrup," "Peace," &c.

Consumption, or Phthisis, hurries off, in the manufacturing towns of Yorkshire, more adults than any other complaint; and the regularity with which she marks out her victims in each year is very remarkable. In Halifax, Huddersfield, and Wakefield, beginning with the year 1841, and going backwards, the numbers in each year are 990, 944, 940, and 910; for Sheffield and Leeds, during the same years, 1,083, 1,198, 1,130, and 1,223. The total difference in

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the healthy districts, during the four years, was 850, or about 212 annually; and this, it is to be remembered, with the additional population of 8,220. The whole number of deaths from consumption, in all the towns compared, are, during four years, 8,418, or about 2,000 a year. It is to be remarked that consumption depopulates these districts, not of the old and very young, but of those in the flower of life—the fathers and mothers of families—and hence bringing in her train misery and destitution. The greatest number of deaths from this disease taking place between the ages of 20 and 30; the next between 30 and 40, and the last between 40 and 50. In Leeds and Sheffield, nearly one-third of the deaths of adults is from consumption, (*i. e.* in 1841 and 1840, the only years for which children are registered, and therefore we are able to know the ages,) while in Halifax, Huddersfield, and Wakefield, they constituted about one-fifth of the deaths. By calculation, the deaths in Leeds and Sheffield are, in proportion for the four years, more than those of Halifax and Huddersfield alone, by 1,000, or about 250 a year.

In comparing Halifax and Huddersfield with each other, it is seen that they are both very similarly affected by this disease. In 1841 there were a few more deaths in Huddersfield; in 1840, a few more in Halifax; and in 1839 and 1838 they were nearly the same in both districts. Comparing Sheffield and Leeds, the deaths are always more in proportion in the former than in the latter place, owing to consumption being excited by the trade of grinding, and which will be named in the sequel.

Typhus fever is another terrible scourger of the human race. In the five Yorkshire manufacturing towns compared, 2,107 died in the four years, being about one-fourth of those who died from consumption, and about one-twelfth of the whole deaths of adults. The number of deaths by typhus

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convey, however, a faint idea of the poverty brought upon whole families by this epidemic, since, for every death there have been from 15 to 18 persons afflicted, and consequently out of work for a long period, and requiring several months for convalescence. It also leaves those who have been attacked predisposed to other complaints; and many registered as cases of pneumonia, gastritis, enteritis, cephalitis, and inflammation, are those who have survived the original complaint, and been carried off by these latter, as sequels of the primary attack. The numbers who died of typhus in the years 1841, 1840, 1839, and 1838, were, in Leeds and Sheffield, 281, 290, 257, and 333,—total 1,181 cases. In Halifax, Huddersfield, and Wakefield, they were 254, 260, 215, and 197,—total 926; the difference in the districts compared being only 64 per annum. These numbers, for typhus, may appear small in comparison with phthisis, but the fatality of this disease is as great in these districts, in comparison with the population, as in the metropolis; being in the latter in 1841, 334 to every 500,000 living, while more than 500 died out of the 500,000 in the Yorkshire towns named. It appears, therefore, that there is more typhus fever in the Yorkshire towns than in London, but that there is equally as much, or very nearly so, in the more healthy districts of Huddersfield and Halifax, as in Leeds and Sheffield,—a medical fact of great importance, to which I shall again refer.

Pneumonia, and other inflammatory diseases of the lungs, are prolific sources of death. During the years 1841, 1840, 1839, and 1838, in Leeds and Sheffield, the deaths from pneumonia were nearly twice as many as in Wakefield, Huddersfield, and Halifax, even with 8,220 additional population.

The few deaths from other chest diseases, as laryngitis, quinsey, bronchitis, pleurisy, hydrothorax, asthma, and unnamed diseases, seem to be about equal in both districts.

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The total deaths from pneumonia and other chest diseases were, during these four years, 2,249 in Leeds and Sheffield, and 1,237 in Huddersfield, Halifax, and Wakefield; being 303 annually in favour of the latter three towns, and that with the extra population beforenamed.

Inflammations of the brain and nervous system, as cephalitis, apoplexy, paralysis, tetanus, chorea, epilepsy, insanity, delirium tremens, and unnamed diseases of the brain, are slightly more numerous in Leeds and Sheffield, being 113 for four years, or 28 per year, more numerous than the same diseases in Halifax, Huddersfield, and Wakefield.

Diseases of the digestive organs, as gastritis, enteritis peritonitis, ascites, ulceration of the bowels, hernia, colic, intussusception, stricture, hœmatamesis, disease of the stomach, pancreas, hepatitis, jaundice, chronic disease of the liver and spleen, are as near as possible alike in both of the districts compared; being for the four years 991 in Leeds and Sheffield, and 980 in Halifax, Huddersfield, and Wakefield.

The number of *deaths above the age of* 60 *years* affords good evidence of the relative salubrity of the districts compared, and shows that more old persons die in the one class of localities than in the other. The numbers, however, are too small to lay much stress upon, being 1,910 for Leeds and Sheffield, and 2,085 for Halifax, Huddersfield, and Wakefield, (for two years,) or about 74 per annum difference.

The whole result, then, is as follows:—That during the years 1841, 1840, 1839, and 1838, (the years contained in the Registrar-General's Statistical Accounts,) there have been 5,593 more deaths in the Leeds and Sheffield districts than in those of Halifax, Huddersfield, and Wakefield, or 1,398 deaths per year; that 2,275 of these were children cut off in Leeds and Sheffield by *scarlatina*, *small-pox*,

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hydrocephalus, teething, hooping cough, measles, croup, tabes and worms; those destroyed by convulsions being nearly alike in number in both districts. That, during each of these years, there were 850 more *adults* who died from *consumption* in Leeds and Sheffield, 255 *of typhus fever*, 1,212 *from pneumonia* or inflammation of the lungs, a few (113) from diseases of *the brain*, while the deaths from disease of the *digestive organs*, and the *convulsions* of children, are nearly the same in number in both districts. I have, therefore, to account for the more numerous deaths of children by *epidemics;* those of adults chiefly from *consumption* and *inflammation* of the lungs; and a small number from *typhus fever* and diseases of the *brain*. And it ought to be found that the similarity of the physical condition of the people of Halifax and Huddersfield, and also of Leeds and Sheffield on the one hand, and the dissimilarity between the two former and the two latter places on the other, will be such, if correctly ascertained, as will represent the predisposing causes to the particular diseases by which the additional mortality is produced, and which, in a great measure, will be found to depend upon the respective Geological positions of these districts.

1. The districts of Halifax and Huddersfield stand upon the same open, friable, fissured millstone grit rocks, and consequently have, 1st. *The same natural drainage*, and this very much superior to that of the districts of Leeds and Sheffield, which stand chiefly upon strata above the flagstone, and which in both localities consist of clays and binds disintegrating into tenacious wet soils. There is abundant proof that good and efficient drainage exercises a material influence over the propagation of epidemics, and that the difference in the excellence of the draining of the Halifax and Huddersfield districts, over that of the Leeds and Sheffield, would be sufficient to account for the

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568 additional yearly deaths by scarlatina, measles, small-pox, &c.

Dr. Southwood Smith, Physician to the London Fever Hospital, says to the Commissioners appointed by Act of Parliament, to inquire into the sanatory condition of the large towns in England, "That the children of the un-"drained districts are more liable than the children of the "higher classes, to the exanthematous fevers (*i. e.* acute "fevers, accompanied by a rash upon the skin, as scarlet "fever, small-pox, measles, &c.) The poisonous condition "of the districts in which they spend the first weeks, "months, and years of their existence, predisposes them "to these dangerous diseases, and renders such diseases "fearfully mortal."

Dr. Forbes, in the *British and Foreign Review* for October last, says (p. 511) "All the reports made to the Health of Towns Commission show that bad sewerage, and an excessive number of deaths among children under five years of age, are coincident. There is no exception to this principle. Glasgow, of course, is no exception; in 1841 and 1842, they were 44 and 49 per cent. In Liverpool, 53 per cent. die at this age.

We may, therefore, conclude that the superior natural drainage of Halifax and Huddersfield, as well as of the sandstone district of Wakefield, aids and assists a superior ventilation of houses, in affording a greater immunity to those districts from these epidemic diseases of children. With respect to *typhus fever*, it does not appear that the superior natural drainage exercises any very great power in checking the ravages of this dire disease, for there is very nearly as much (the difference being only 64 persons per annum) typhus in the districts of Halifax, Huddersfield, and Wakefield, as in Leeds and Sheffield, and considerably more in every one of these places than in London. Medical men, however, are not agreed of what the predisposing causes

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of typhus really consist; some attributing them to want of draining, bad ventilation, and the accumulation of filth, in a word, to *malaria;* while others again deny their influence. Of the former are Dr. Southwood Smith and the other medical men examined by the Commissioners; while of the latter are Dr. Graves, of Dublin, Professor Alison, and Dr. Watts, of Glasgow. And certainly the fact that in the well-ventilated, drained, and airy districts of Halifax and Huddersfield, there is nearly as much typhus as in Leeds and Sheffield, affords upon an extensive scale the strongest evidence that malaria is very little concerned in its propagation. As the Commissioners will no doubt recommend Parliament to act upon the evidence afforded in our large towns, it may be well to give one or two opinions of the medical men with respect to the metropolis and other places.

Dr. Southwood Smith, Physician to the London Fever Hospital, says, "In every district in which fever returns frequently and prevails extensively, there is uniformly bad sewerage, a bad supply of water, a bad supply of scavengers, and a consequent accumulation of filth; and I have been accustomed to express the fact in this way. If you trace down the fever districts on a map, and then compare that map with the map of the Commissioners of Sewers, you will find that wherever the Commissioners of Sewers have not been, there fever is prevalent; and on the contrary, wherever they have been, there fever is comparatively absent." He is again asked, "Are you aware that the rate of mortality is actually found to be nearly double in some of the neglected districts in the East, compared with what it is in the Western part of London?" "I am; and this interesting and important fact is dependant on several circumstances, and not on any one cause. Thus, a large portion of the people who reside in the Western

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part consist of the wealthier, while the Eastern part is principally inhabited by the poorer classes. The higher value of life indicated in the Western district is partly owing to the better food and clothing of the wealthier classes, to their more temperate habits and less exhausting labour, and especially to the better care taken of their infants and children, and in general to the more favourable circumstances under which childhood and infancy, the most precarious and mortal epochs of human life, are placed. But still the poorer classes in these neglected localities and dwellings are exposed to causes of disease and death which are peculiar to them, the operation of which is steady, unceasing, and sure; and the result is the same as if 20,000 or 30,000 of these people were annually taken out of their wretched dwellings and put to death; the actual fact being that they are allowed to remain in them and die. I am now speaking of what silently, but surely, takes place in the metropolis alone, and do not include in this estimate the numbers that perish from these causes in the other great cities, and in the towns and villages of the kingdom. It has been stated that the annual slaughter in England and Wales, from preventable causes of typhus fever, which attacks persons in the vigour of life, is double the amount of what was suffered by the allied armies in the battle of Waterloo." This is no exaggerated statement; this great battle against our people is every year fought and won; and yet few take account of it, partly for the very reason that it takes place every year. However appalling the picture presented to the mind by this statement, it may be justly regarded as a literal expression of the truth. I am myself convinced, from what I see of the ravages of this disease, that this mode of putting the result does not give an exaggerated expression of it. Indeed, the

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most appalling expression of it would be the mere cold statement of it in figures. Drains, to be efficient, according to the same authority, must be flushed with water, and this in all the smaller ones can only be accomplished at great expense. Dr. Southwood Smith goes on to say, (p. 995,) "No drain can be efficient through which there do not flow currents of water. Without a provision for this regular and abundant supply of water, drains not only fail in accomplishing their object, but they become positively injurious. They generate and diffuse the very poison, the formation of which it is their object to prevent; and the extent to which at present poison is thus actually generated and carried forth, may be accurately measured by every inch of drain which is not regularly washed by a good stream of water."

Dr. Graves, one of the Physicians to the Meath Hospital and County of Dublin Infirmary, states in his "*Clinical Medicine*," (p. 42,) "For a considerable period there was a great tendency among physicians to refer the origin of typhus, and almost every variety of fever, to malaria, or unwholesome emanations from the soil, produced by the decomposition of vegetable matter. In Ireland, facts do not bear out this hypothesis, for when an epidemic of fever has become established, it breaks out simultaneously in situations the most different, and in some where no such emanations can be supposed to exist. Thus, I have seen a whole family affected in the telegraph, situated at the summit of Killiney, a mountain formed of bare granite; and, indeed, the granite and mountain districts beyond Rathfarnham, Tallaght, and Killikee, supply the Meath Hospital with its worst cases of typhus." He quotes Major Tulloch respecting the troops in the Colonies, where it clearly appears that fevers of the most malignant character frequently arise

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in places presenting a combination of circumstances most favourable to the exclusion of malarious influence, and concludes by saying, that the most improved and thoroughly-drained towns and country districts are quite as liable to epidemics of typhus as are the most neglected and marshy parts of our island.

Professor Alison says, "The vitiation of the atmosphere by *putrescent animal or vegetable substances*, or by *crowded human beings*, has been supposed to be a sufficient cause (of continued fever), and the former of these opinions has been much espoused in England; but so many instances have been collected by Dr. Bancroft, Dr. Chisholm, Parent Du Chatelet, and others, of both these causes being fully applied without any such effect; and it is so easy to explain the frequency and rapid diffusion of continued fever in the situations where such effluvia exist, by the concentration of the contagious poison and other circumstances and mode of life of the inhabitants, that we must set aside both hypotheses."

Dr. Duncan, of Liverpool, and Dr. Watts and Dr. Perry, who have written upon the fever of Glasgow, assert that the cause is to be sought for rather in the want of nutritious food than of pure air.

Other evidence from the Yorkshire districts might be advanced, showing that malaria has little or nothing to do with either the generation or spread of typhus. Wadsley village, built upon bare rock, and one of the best building stones in Yorkshire, consisting of detached well-built stone houses, with high elevation and gentle declivity, is scarcely ever free from typhus fever. The same may very nearly be said of Monk Bretton; and Little Smeaton, upon the magnesian limestone, and situated upon the bare rock, with a rapid declivity, has frequently in it some very severe cases; while Womersley, a low damp malarious village, has

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not had a single case in it for fifteen years. York City, most wretchedly drained, had only,

In 1841.....	20	cases.
1840.....	33	„
1839.....	18	„
1838.....	11	„
	82	
Average.....	20	out of 32,000 population; much less than in the West-Riding towns.

Probably a mean or combination of these opinions may be the true one; and it will be found that the predisposing causes of fever are all agencies which debilitate the system, or which are allied to, or increase, the effects of the contagious virus, which is the *materies morbi.* Several of these do co-exist in towns. Thus, hardships and innutrition weaken the body. Malaria, we know, will cause one kind of fever, and probably propagate typhus; and a deficient supply of pure air will render the disease more fatal. Hence, in Halifax and Huddersfield, typhus is more probably due to innutritious and a scanty supply of food, and long hours of exhausting labour within doors, than to any malarious influence.

2. The next Geological advantage which Halifax and Huddersfield have over Leeds and Sheffield is, that the former have upon the spot *excellent building stone, and consequently the inhabitants have good houses, good streets, and larger rooms in their houses.* The buildings in Leeds and Sheffield are chiefly of brick. The small quantity of stone used in Sheffield is brought three miles, from Wadsley, and the little in Leeds about two or three miles, from Bramley Fall, and Woodhouse Moor and Roundhay. The houses in Sheffield are notoriously small; and in the old parts of the town particularly, adjoining the River Sheaf, are to be seen

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innumerable courts, with four and five houses in each, and forming a complete *cul de sac.* The houses in above half of Leeds, particularly Hunslet, Marsh Lane, &c., are of very inferior description, and many are built upon the potters' clay, out of which the bricks were made to build them. Superior houses, streets, and rooms, induce a greater degree of *cleanliness, and also a better ventilation,* or an easier access of pure air frequently renewed; a superior well-built house also admits more solar light. The stunted growth of the Samoïed, the Ostiaks, the Esquimaux, the Greenlander, and the Laplander, deprived nearly two-thirds of the year of solar light, indicate its great utility to healthy frames.

Dr. Laycock, in his Report on the Sanitary State of York, asserts that an elevated situation is of the first importance in that city, and that the variations in altitude from only 13 to 45 feet above the level of the Ouse, gives to different parts of the city a mean age at death of from 22 years to 42½; and that, even in the labouring class, there is a difference of 12¾ years. The greater elevation affords a superior ventilation; but Dr. Laycock adds, that the effects of deficient drainage are not to be avoided by good ventilation; and, as a proof, names two villages near York, both well ventilated,—that of Rufforth, having a wide stagnant ditch passing through the village, where the mean age at death is 28 years, and that scarlatina there was termed the "black death;" while the mean age at Acomb is 35½.

Dr. Emerson, in a paper on the Medical Statistics of Philadelphia, says, "Whilst upon the subject of public hygiene, we cannot restrain ourselves from noticing the subject of ventilation, or a proper supply of pure unrespired air. By far the greatest proportion of the annual sickness and mortality of ordinary seasons is furnished by the narrow

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and confined alleys and courts, existing in various parts of the town. The low terms upon which the small houses and rooms can be obtained, causes them to be crowded with a population negligent of cleanliness; and it ought to occasion no surprise that there is greater sickness and death among them compared with those living in larger dwellings, having a *freer circulation of air.*" He also states that the effect of this bad supply of pure air is most lamentably conspicuous among children.

It is also well known that you may place cases labouring under malignant typhus, in a room with other infirmary patients, provided there be good ventilation, with perfect impunity. The experiments were made in the infirmary of Edinburgh, and detailed p. 286 of the Report by Dr. Arnott. It was found in the wards occupied by fever patients only, that the nurses and other attendants rarely escaped infection; but when such patients were scattered about so as to dilute the poison, the attendants remained safe, as did also neighbours in the beds about them; proving that dilution of the contagious poison, by scattering the patients, as well as the complete ventilation of a fever ward, affords safety.

Dr. Arnott says, it is known that a canary bird, suspended near the top of a curtained bedstead in which people have slept, will, generally, owing to the impurity of the air, be found dead in the morning; and small close rooms in the habitations of the poor are sometimes as ill-ventilated as the curtained bedstead. But small badly-ventilated dwellings are favourable to the production of *consumptive disease*, which destroys more adults than any other complaint. There is no doubt that the proximate cause of phthisis is tuberculous deposits in the upper portions of the lungs, which consist of albuminous fluid mixed with imperfectly developed cells or cyloblasts, but which,

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themselves, are developed in certain constitutions, upon a proper exciting agent or irritation being applied. Under the microscope, there is no difference between the tubercle or bleb, caused by rubbing croton oil upon the skin, and that produced in the lungs, and which leads to consumption. Like gout, phthisis is either hereditary or may be acquired, and the disease is said by Dr. Maxx scarcely to occur at all in Egypt; and it is also stated that in countries where aqueous exhalations cause intermittent fevers, phthisis is little known. Dr. Guy, professor of forensic medicine in King's College Hospital, in the Commissioners' Report gives ample proof of the injurious effects of deficient ventilation. He states the proportion of consumptive cases in the three classes of persons, viz:—gentlemen, (including professional), tradesmen, and artisans, as 16.28 and 30 per cent; so that the tradesmen of the metropolis are nearly twice as liable to consumption as the gentry; and the greater mortality, Dr. Guy thinks, is mainly attributable to their confinement during so many hours of every day in ill-ventilated shops, and, especially, when dust is inhaled and gas-burners are used. He further states, that about 36,000 persons in England and Wales die of true pulmonary consumption, and that by proper sanitary measures, not less than 5,000 might be saved. It appears again from the researches of Dr. Carpenter, that at each inspiration 20 cubic inches of air is taken in, and, therefore, 266⅔ cubic feet in 24 hours. But Dr. Guy adduces some cases where 104 men, working in a room with less than 500 cubic feet of air to breathe in, were affected by spitting of blood, catarrh, and other lung diseases, to the amount of 42 per cent.; while 115 men, having from 500 to 600 cubic feet, were affected to 27 per cent. with the same complaints; while 101 men, with more than 600 cubic feet, were affected only to the amount of 23 per cent.

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From these facts, therefore,—from the known inferiority of the buildings in Leeds and Sheffield, in comparison with the larger streets, better houses, possessing larger rooms, all of which are due to superior Geological site,—I conclude that the deaths of 850 persons by consumption are mainly to be attributed to the want of ventilation, or a free access of pure air to the lungs of the people inhabiting these districts.

3. The *influence of light*, and a more elevated and cheerful situation, cannot be overlooked. Sir James Wylie states that the cases of disease on the dark side of an extensive barrack at St. Petersburg, have been uniformly for many years in the proportion of three to one to those on the side exposed to strong light. N. B. Ward, Esq., says that light, during childhood, directly influences the physical development. Dr. Edwards's experiments are conclusive, that if tadpoles, however well nourished, are entirely deprived of light, their metamorphosis into air-breathing animals is arrested, and they remain in the form of large tadpoles.

Dr. Craigie says, (*Practice of Physic*, p. 442,) "The causes of pneumonic inflammation are in general those which induce inflammation in general. All observation concurs in showing that, though it may occur at any period of the year, it is chiefly a disease of the cold seasons, and especially the cold seasons in temperate countries. It prevails chiefly after the winter solstice, between the close of December and the end of April, or even of June." Dr. Copland says that the incautious exposure to cold or wet, and to the night air, after breathing for some time the foul or depressing air of a confined or crowded apartment, or ill-ventilated quarter, bed-room, or barrack-room, is, perhaps, the most productive cause of pneumonia, particularly in large towns; and explains the greater prevalence and mortality of the disease in these circumstances, than in open healthy localities. I therefore conclude that the naturally damp soils and subsoils of Leeds

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and Sheffield, every square yard of whose streets requires paving to prevent evaporation, together with their inferior-lighted and low situated dwellings, are sufficient causes to produce the additional 1,212 deaths from pneumonia or inflammation of the lungs.

4. Another superiority in Halifax and Huddersfield and Wakefield, over Leeds and Sheffield, *is in the Geological nature of the soil and subsoil;* the one being open and porous, and which, according to the experiments of Schübler, has the power to hold or contain only 25 per cent. of water, while that of stiff clay or brick earth will hold 61 per cent.; or every cubic foot of the former will hold only 27.3 lbs. of water, and the latter 48.3 lbs., or nearly double the quantity; consequently, there will be double the evaporation of moisture in the latter towns over that in the two former. Now in a moist state of the air the changes are not fully effected on the blood by respiration—its watery portions are not carried off so freely from the exhaling surfaces—its purity is diminished, thereby rendering the powers of life more languid, and the system more open to the invasion of the exciting causes of disease in general.

Dr. Emerson, speaking of the mortality of Philadelphia, says, "Great as was the amount of sickness, it was confined almost entirely to the comparatively small proportion of population inhabiting the unpaved or ill-paved environs. Our observations led us to ascribe this exemption, for the most part, to the pavement, which, by effecting a perfect draining, *prevents exhalation*, at the same time that it admits of the total removal of animal and vegetable matters. The chief motive for paving the streets and side walks is usually convenience, but it has always appeared to us that by far the most important object achieved by it was the preservation of health."

5. There is, no doubt, a close connexion between the *qualities of water* and the Geological character of its locality.

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How far these may influence health in distant localities seems not easy to determine. Those containing vegetable and animal matters are positively injurious. The degree of hardness is very material in an economical point of view, as connected with the consumption of soap. I hope by Dr. Clarke's method, (Professor of Chemistry in Aberdeen,) by the soap test and acid test, to obtain the hardness due to both neutral and alkaline earthy salts, of the waters chiefly used in these towns. The waters of Halifax and its neighbourhood have already been described by a distinguished Member (Dr. Alexander) of our Society. So also have the waters of Yorkshire been analysed by Mr. West. It would, however, be presumptuous to assert, without more information upon the subject, that any degree of unhealthiness is to be attributed to the difference in the quality of water.

Exceptions. — The perturbations which, within certain limits, counteract those prevailing laws of mortality which are produced by general Geological causes are—1. *Density of population;* 2. *The trades or occupations* of the people of each district; 3. *Epidemics*, acting partially.

1. *Density.*—In two towns, both having the same Geological advantages or disadvantages, but the one having twice the population per acre—this greater density may, I do not say will, within certain limits, alter their rates of mortality. For example, Sheffield has 5,155 persons to the square mile, while Leeds has only 2,416; their rates of mortality are, nevertheless, the same, *i. e.* for 1840, 1841, and 1842. But it is absurd to assert that the mortality increases with the density of the districts, as the Registrar-General, in his Fourth Report, page 15, states. Birmingham has a population of 33,255 to the mile—eleven times as many as Leeds, and five times as many as Sheffield, and yet their rates of mortality are the same. While again Manchester has only 9,525 to the mile, and yet its rate, 3.2, is much higher than that of Birmingham, and only second to Liverpool, which is

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the most unhealthy town in England. While again Clifton has only 1,713 persons to the mile, and yet its mortality is as great as Bradford, viz., 2.4 per cent., which is very densely populated.

The trades and occupations of each district are also, within certain limits, perturbing causes; for not only do the different employments exert a material influence upon health, but their prosperous or adverse states do so likewise. The grinders of Sheffield amount only to 3,000, and, therefore, their numbers do not influence the rates so much as might be supposed. (See Dr. Calvert Holland.) It is, however, a most appalling fact, from inquiries made in 1822 respecting the phthisis of the grinders of Sheffield, that out of 2,500 grinders, there were not more than 35 who had arrived at the age of 50; and not double that number who reached the age of 45; and that out of 80 fork-grinders, exclusive of boys, there was not a single individual 36 years old. Sir Arnold Knight, who has written an account of the grinders' asthma (*in the North of England Medical and Surgical Journal*, p. 89,) concludes by asking, "Might not criminals, who have grossly violated the laws of their country, be condemned for life to fork-grinding, as for minor offences they are sentenced to the tread-mill?" It appears, however, that in the years 1839, 1840, and 1841, the average age of all who died above 21, engaged in the manufactures of Sheffield, was 48; *i. e.* without gentry and tradesmen, with them 52; and that the average age of fork-grinders was 48 years,—other grinders 44.09.

It does not, however, appear, during the same three years, that the rate of mortality of the persons connected with the manufacture of woollen cloths in the Huddersfield Union, are very different from the trades of Sheffield. The average age of all who die is 46, and, therefore, less than the artisans of Sheffield. The average age in the Society of Friends for 1841, 1842, and 1843, of those who died above 20 years,

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was 62.40. No statistical account of those employed in the manufacture of woollen and flax in Leeds has yet been published, but there is good reason to believe that the great mass of disease constantly witnessed in our manufacturing districts, flows from the great towns, with badly-constructed dwellings, narrow streets, imperfect drainage, and confined working rooms, more than the *factory system* itself. Dr. Knoltz, of Vienna, has lately published an account of the management of cotton mills in Lower Austria, where he proves that factory working, *per se*, is not more prejudicial to health than most other occupations. We gather from his publication, that the hours of labour in the cotton mills are more extended than in our own country, and yet that the health of the operatives is in a better condition than that of other classes of workpeople; attributable to the excellent sanitary regulations of the country. The factories described by Dr. Knoltz are situated, not in the centre of large cities, but in hamlets, villages, and small country towns. Most of these districts are open plains, well exposed to the air. He says all considerations relating to the healthiness of the foundations and site, security against fire, and other collateral circumstances of this kind, are determined by the authorities, prior to the erection of the mills, and every advantage is taken to secure the probable health of the future work-people. In building, every care is bestowed upon the height and width of the rooms, and upon the facilities for ventilating them; and further, in the immediate vicinity of the work-places are built dwellings of a very superior character, the property of the mill-owners, for the operatives themselves, as well as apartments for their treatment in sickness, and also schools and residences for the teachers. The due management of all these matters is rendered obligatory upon the occupiers of the establishment by the Government of the country. He further states that the children of the operatives are better

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educated and fed than those of the other villagers, and being removed from the bad example furnished in large towns, are strangers to the vice and delinquencies of corresponding classes in France and England. The men work in lofty rooms, which are kept in the cleanest state possible, well heated by Messner's stoves, or by hot water in tubes in winter, and most carefully ventilated in summer. That every where near the larger mills infirmaries are instituted, and furnished with well-paid physicians and surgeons, in order that all adults, as well as children, may receive appropriate care and attention during illness; and in all cases of epidemic disease, the mill-owner is compelled, by existing regulations, to provide every thing at his own cost. And as the successful result of these arrangements, that during the prevalence of the cholera in 1832, in the largest factory in the monarchy, at Pottendorf, where upwards of 1,200 persons are employed, only three fell victims to this pestilence. He also affirms that there is no unusual mortality among the factory workers, and that the sickness is greater amongst the children of the villages unconnected with cotton mills. That the establishments are usually in full work about fifteen hours a-day, and the young children are engaged in actual work about thirteen hours.

As a third disturbing cause, *epidemics may act partially*, *i. e.* if Leeds be visited with scarlatina, or small-pox, or measles, while Sheffield is not, as in the year 1839, (the deaths in Leeds were nearly 400 from measles, while those in Sheffield were 33,) such a circumstance will tend to alter their respective rates of mortality; but in a sequence of years, it is highly probable that the mortality from epidemics will be nearly balanced, for their progress all over the kingdom is governed by certain general laws, going through a regular course, and declining; thus, five persons die weekly in the metropolis from small-pox, but when the disease becomes

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epidemic, the numbers rise to 10, 15, 20, 31, 58, and 88 weekly, and then progressively fall through the same measured steps. They also march through the kingdom in a sort of natural order, as the small-pox epidemic, destroying 30,812 persons during two winters, two springs, three summers, and three autumns, progressed first on the West side of our island, from Liverpool, up to the metropolis, then raged into the Midland districts, and reached Norfolk, and came down by the Eastern coast to Newcastle-upon-Tyne.

What, then, are the remedies proposed for this enormous annual waste of life, as a deduction from the preceding facts?

1. As in Lower Austria, *no factories or mills be permitted to be built in large towns for the future;* and this step is necessary for the improvement of the sanitary condition of our most rapidly increasing population in the West Riding towns. Leeds, which 40 years since contained only 53,162 inhabitants, is now *trebled*, to 152,054; Sheffield, in 1801, had 31,314, and is now more than *doubled*, to 68,186; Bradford, which in 1801 contained only 6,393, is now multiplied nearly *six times*, to 34,560; Huddersfield, from 7,268, increased to 25,068; Halifax, from 8,886, to 19,881; and Wakefield, from 8,131 in the year 1801, to 14,754 in 1841.

2. That certain Geological sites be chosen for these mills, when practicable, as a rocky, elevated, and dry locality, with good stone contiguous, since the workmen's houses eventually will follow the mills, and the quality of the adjacent building materials, whether stone or clay, will determine the size of the streets, houses, &c.

3. *Respecting the houses, &c.*—That building acts compel the drainage, paving, and sewerage of the streets and foundations, before being built upon; that the rooms of both

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houses and mills be made of certain sizes, and capable of being ventilated by the admission of currents of fresh air, due regard being paid to the construction of sufficiently wide streets for the admission of light; and also that a due quantity of good water be supplied. In a word, more attention to the comforts of the labouring classes.

The employers of our labouring classes require to be taught that their own prosperity, and that of the community, is concerned in their welfare; and that if, by sanitary regulations, we can add a few years to the allotted span of human existence, we afford to the artizan not only that which he prizes above all wealth, viz., life, and add happiness to the common stock, but we are acting in conformity to the will of the Great Author of that life, by prolonging and preserving his great gift as much as is compatible with human power.

At the conclusion of the paper, an interesting discussion ensued, on the various points mentioned by the Rev. Gentleman.

Dr. Crowther said, his opinion was, that a deficiency of water caused a great mortality. He had no faith in the notion that high and airy situations were always the best. For instance, when the building of the new prison at Wakefield was under consideration, it was mooted by some that Park Hills would be a much healthier situation than the valley in which it at present stood. Had the site of the prison been removed to the Park Hills, he (Dr. C.) gave it as his decided opinion that the mortality would have been increased ten times. There was Ardsley, a supposed healthy situation on a hill, which was hardly ever free from typhus fever, while in Wakefield there was scarcely ever a case; thus, in his opinion, showing that it was water, and

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plenty of it, which was wanted. He did not think the quality was so much an object as quantity.

Mr. C. Morton would ask the author of the paper if there was any established rule between mortality and Geological position? With respect to some of the figures brought forward by the Rev. Lecturer, he thought the rate of mortality in some towns excessive. He would like to ask the Lecturer, if the Geological position had such influence upon mortality, how it happened that London, with its clay foundations, and Halifax, with its grit rock, were so near alike?

The Rev. W. Thorp said, that if the rates of mortality from the Fifth Report of the Registrar-General were examined, there would be found very great variations, according to locality, such as neither density of population, trades, &c., could account for; and this paper sought to establish a connection between the degree of the salubrity of any place and its Geological site. The rates of mortality, however high, were all extracted from the Reports of the Registrar-General, and were, therefore, correct. Mr. Morton had not rightly comprehended him respecting London; the rate of mortality of the metropolis is 1 in 37; agreeing nearly with Hull, (1 in 34,) which is also built upon clay. Halifax and Huddersfield have rates of 1 in 50.

Mr. Briggs thought the quality of water had more to do with the health of a town and neighbourhood than appeared to be admitted. He had frequently observed, that where the water was hard, there was more disease than where it was of a different character.

Dr. Crowther did not think the quality of the water had much to do with health. He wanted the people to have plenty of water, and, if the quality was inferior, it would not make much difference, in his opinion.

Dr. Inglis, of Halifax, thought differently. The quality

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of water either increased or decreased mortality to a considerable extent. The Doctor instanced a village near Halifax, which he did not name, where the water was bad, and the inhabitants were never free from disease; but in every other respect it stood advantageously.

Mr. CLAY said, he thought there was most typhus, for instance, on the brow of hills looking south, and supported Dr. Inglis and Mr. Briggs with respect to the quality of water.

Dr. CROWTHER said, some 30 years ago, an epidemic broke out with violence every year at Daw Green, near Dewsbury. For several years it was difficult to ascertain any cause. The inhabitants had an ash-heap, and it was customary to remove the ashes every May, and immediately the disease was raging. One year it was removed at Christmas, and the following summer the place was healthy. The ashes were afterwards removed at Christmas, and the disease had not since appeared. He maintained that the drainage of towns had considerable influence upon health. In his opinion, no good could be done until the legislature passed an act compelling a proper drainage. For instance, some years ago, the Commissioners of the Wakefield Streets laid out £700 in taking a drain from the Ings to the top of Northgate, and it was surprising how few owners of cottage property had availed themselves of it. None, in his (Dr. C.'s) opinion, but compulsory measures, would effect the desired good.

The thanks of the Meeting were then voted to the Chairman, and to the Rev. Wm. Thorp for his able paper, and the Meeting adjourned.

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE TWENTY-EIGHTH QUARTERLY MEETING, HELD IN THE HALL OF THE PHILOSOPHICAL SOCIETY, HALIFAX, ON WEDNESDAY, MARCH 12TH, 1845.

JOHN WATERHOUSE, Esq., F.R.S., was called to the Chair.

On the motion of the SECRETARY, Dr. J. D. HEATON, of Leeds, was elected a Member of the Society.

The following paper was then read:—

ON VIBRATIONS PRODUCING SOUND. BY WM. SYKES WARD, ESQ., OF LEEDS.

In considering the nature of light, it has appeared to me of importance that the phenomena of small vibrations, and especially those producing sound, should be fully and independently investigated; not on the ground that any supposed analogy would be conclusive, but that as the undulatory motion of light has, to some extent, been presumed to be analogous to the motion of sound, it might be well to ascertain whether the production or propagation of sound is by undulatory or by progressive motion.

It is readily perceived that sound is not substantial matter—that sound does not occur unless produced by

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some body which is capable of vibrating; for instance, in an absolute void there could be no sound, and a very slight investigation shows that unless some body, be it solid, fluid, or gaseous, be present, sound, if even it might be produced, cannot propagate itself.

As it appears of much theoretical importance to ascertain whether sound can be produced without primary vibration, that is, vibration generating the sound, disregarding for the time the question whether sound is transmitted by vibrations, it is important to notice an instrument of French invention, called the Syrene, in which streams of air acting upon a disc, pierced with twenty-five small holes, arranged in a circle and drilled obliquely, cause the disc to revolve, so that in revolving the disc acts as a valve, alternately closing and opening the apertures twenty-five times in each revolution, and the air passing through the disc when revolving, rapidly produces a musical tone, which appears to be produced by the interrupted impulses of the air, and not by vibration.

As nearly all other phenomena of sound are the effects of vibration of elastic bodies, it will be advantageous to pay close attention to some of the properties of elasticity. All known bodies yield or are compressed in a slight degree, when they are struck by or impinge against another hard body; and the bodies which are termed elastic, after such compression, return to their original shape; but other bodies have the property of elasticity only in a very low degree.

Elasticity may be defined to be the property which enables the particles of a body which have been slightly disturbed to return to their original positions. But we are ignorant of even the more approximate causes of elasticity, and we shall remain in ignorance of many similar and apparently very simple properties of bodies, until the intimate con-

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stitution of matter has been much more fully investigated than has yet been done.

The motions produced by elasticity are generally very small, and as many of the motions of sonorous bodies are of this nature, some of the peculiarities of such small motions demand attention; amongst the most remarkable of these we shall find that a very large mass of matter may be put in vibratory motion by a very small force; for instance, a very slight stroke will make a large bell sound; showing that although vibratory motion is not altogether freed from the obstacle of *vis inertiæ*, yet the *vis inertiæ* is easily overcome, from the circumstance that a small number of particles are at first moved, and then communicate their motions from one to another; and in vibratory motion the particles of matter move upon each other almost without friction.

Another important property of vibratory motion, is that of accumulation from a continuance of the vibratory force; thus a very heavy pendulum may be set in motion by an apparently very inadequate force, applied in accordance with its time of vibration.

Again, vibratory motion communicates itself with remarkable freedom to all the particles of the vibratory body, which are in a relative vibratory position; thus, if one side of a glass goblet be struck, the vibration is instantly communicated to the other side.

If a solid body be struck in almost any manner, vibration will result, and will communicate itself to the air, so that sound will be heard. If the body struck be so circumstanced that it cannot vibrate freely, and maintain a succession of regular vibrations, the sound produced will be what is called noise; but if the body can vibrate regularly, and continue its vibrations at a rate exceeding sixteen pulsations in each second of time, a musical tone will be produced, more or less

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acute as the pulsations are frequent; and the tone will also be of a fine or agreeable quality in proportion as the pulsations are uniform and free from irregular vibrations. Thus, if a common table be struck the sound is merely noise, for although vibration is produced, yet the pulsations are irregular and do not continue, for the material and form of the table do not permit uniform or equal vibrations; and if the parts of a body vibrate in different and discordant periods, the vibrations check each other, and soon cease. But if a bell or a plate of metal freely suspended be struck, the vibrations produced become regular in their periods, are maintained a considerable time, and a musical tone is the result. The velocity of the vibrations of the metal is found to be in accordance with a function of the weight and the elasticity of the metal put in motion; and the pitch, or acuteness of the sound, is always in accordance with the number of vibrations in a second of time, however the vibration be produced. If a string be stretched over two supports, technically called bridges, the string will naturally remain at rest in the imaginary line between the supports, and if removed from the line, will, when set free, return to it, but the acquired velocity causes the string to pass the line, and to make several oscillations on each side of it;—these oscillations or vibrations communicate themselves to the surrounding air, and, as in the former examples, musical tones result; and the number of vibrations per second is found to be in accordance with the tension and the mass of the string. Thus, if a string be stretched by a given weight and the tone observed, and the weight be then doubled, the tone will be found to be eight notes or an octave higher in pitch than before, the velocity of the vibrations being doubled; and if a string of half the weight to the same length be substituted, and the like weight be used, the tone will be found to be as high as when the thicker string and

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the two weights were employed. If the string be shortened, (or only a portion of it permitted to vibrate), the tones will be found strictly in proportion to the length vibrating. Thus the tone produced by half the string will be the octave of the note produced by the whole string.

Not only do plates, strings, and solid bodies produce regular vibrations, but also the air and gases. But to produce regular and sensible vibrations, the air must be confined to some extent; for instance, in a tube either open or closed at one end. The vibrations of a column of air are very similar to those of strings in many respects, but differ materially in others. An open diapason organ pipe of 32 feet in length is found to give about 16 vibrations,—a pipe of 16 feet gives 32 vibrations per second; and the vibrations produced by shorter pipes are in like proportion.

But the weight or volume of the air vibrated does not materially affect the pitch; and if we take an organ pipe of narrow bore, and take another pipe of larger bore but of the same length, on blowing, a tone of nearly the same pitch will be produced. If, however, the tube be sounded by warm or rarer, instead of cold or denser air, the pitch will be found higher. The density, therefore, of the air or gas is analogous to the weight of the string.

There are no correspondent phenomena of tension, and the phenomena of actual mass and weight in the string and in the column of air are quite incongruous; but the apparent discrepancies cease when we consider that a bar of iron is capable of vibrating longitudinally as well as laterally, and that it is most probable that the vibrations of a confined column of air are altogether longitudinal, and not lateral, as are the vibrations of the string.

The vibrations of a body are disturbed or prevented by a slight obstacle, but when the disturbing force is very slight, the stopping of the vibrations may be partial,

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especially if the portions of the body be so equally divided by the obstacle, that two or more are left capable of vibrating in like times; and having also seen how easily sympathetic vibrations are induced, we shall readily comprehend that vibration will be communicated from one part of the body to the other or others. Thus, when a string is vibrated, and the finger is slightly applied exactly at the middle of the string, the portion touched by the finger cannot vibrate, but the string is divided into two halves, each of which are capable of vibrating in like times, and the string will, therefore, vibrate in two portions, producing the octave of the fundamental note.

In like manner, if the string be touched at the 3rd, 4th, 5th, 6th, or any multiple part of the whole, it will in vibrating divide itself into as many parts, vibrating in unison, separated by points at rest, which are termed nodal points.

A column of air divides itself into different vibrating portions more readily than a string; thus, with the flute, when an aperture is opened at the 1st, 3rd, or 4th of the tube, nodal points are produced in like manner as when a string is touched, and similar harmonic tones are produced; and the like harmonies are also produced when the air is more strongly introduced into the instrument, the primary vibrations being more accordant with the production of high than low notes; the column of air in the flute may thus be divided into as many as eight parts.

The vibrations of glass goblets or metallic vessels of similar shapes do not appear to give the strictly fundamental vibrations, but only the harmonic corresponding to the 4th in the series on a string; for the hemispherical form does not so readily permit vibration to take place by the change of the entire form, as by a change of form in four or more segments alternating with each other. This appears the more probable, as we cannot produce the vibra-

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tion corresponding to the 5th on the string, but the 6th is readily produced when the glass is vibrated by a violin bow.

These vibrations and the nodal divisions are made apparent when the vibrated vessel is about half full of water, the movement on the surface of which points out the number of divisions in which the glass vibrates.

But when plates of brass are employed, and the vibrations are excited by a violin bow, harmonic vibrations may be produced to a very considerable extent; and as was, I believe, first observed by Chladni, the situation of the nodal points, which in these instances become lines, are very beautifully shown by strewing a little fine sand over the plate, and which, by the violence of the vibration, is thrown from the parts of the plate which are in strong vibration, but remains on the lines formed by the portions between the parts in vibration which remain quiescent.

It might be supposed that the harmonies of plates would follow in similar succession to those produced by strings; but this is not the case. However, the anomaly of these tones may be resolved by the consideration that plates vibrate differently, according to the manner in which they are suspended; that is, a long plate suspended or fixed at both ends, in a situation to vibrate, gives tones an octave higher than a similar plate fixed at one end; and a square plate fixed at two of its sides, gives similar vibrations to another square plate of four times the area, fixed on all its sides; as will be readily perceived on careful inspection of the figures of sand on such plates. And it will be seen, that on a reduction of all the vibrating portions of the plate to that of figures bounded or fixed on all sides, the vibrations will be those of ideal plates of different sizes; and also that some parts of the plates between the figures or vibrating portions are at rest; thus accounting for the

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apparent anomaly of the tones produced, especially where the tones differ by about half a tone from that of the true interval of the proper harmonic tones.

It is well known that bells, in addition to the primary vibrations, which are similar to the lower tones produced from plates, give harmonic vibrations at the same time. We may, therefore, perceive the reason of the great difference in the tone of large bells; all have harmonic tones in addition to the primary tones, but from differences in the disposition of the metal of the bell, there may be produced harmonic tones discordant to the primary tones.

The appearance of progressive motion may be produced by bodies moving only in direction transverse to that of the apparent progressive motion. It is known that the motion of waves on the surface of water is of this nature, for on observing a small body, as a piece of cork, on the surface of the sea, the cork is seen to move up and down, but does not partake of the apparently rapid onward progress of the wave. This motion we will, therefore, term wave motion.

But in observing the property which small elastic bodies possess of communicating their motions one to another, and yet appearing themselves to be at rest, it appears that we discover a path which, being carefully pursued, may lead us to right apprehension of many of the phenomena of small but rapid motions; probably of those mysterious agents which are now comprehended under the term Actinism, a term suggested by Sir John Herschell, and agreed by the Physical and Chemical Sections of the recent meeting of the British Association at York, to be for the future the general designation of radiants, whether light, heat, or chemical rays.

By means of a few marbles suspended by threads, it will be observed, that when one of the marbles is made to impinge against the others, the motion is communicated

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through the line with greater velocity than the impinging marble would travel through the like space, and that the furthest or external marble is driven off with nearly the same velocity as the impinging one had acquired, the intermediate ones remaining apparently at rest, (at least as regards the first impulse.) This I will beg to term motion by impulse, or impulsive motion.

It is easily perceived that sound is not the actual progressive motion of the whole body of air affected by it, for the motion of sound is not generally accompanied by apparent force, (except in some extreme cases, as when windows are broken by the sound of cannon); and as I am not aware that any other species of motion, other than wave motion or impulsive motion, or one of these combined with a small amount of actual motion, have been suggested as the motion of sound, we will endeavour to form some opinion whether the supposition of wave motion, or of progressive motion, is the most probable, and which, with the least difficulty, supplies the explanations required by the known phenomena of sound.

It is, I believe, a very general opinion that the progression of sound is by waves; this, perhaps, is from the force of early impression, from the comparison of the formation of sound to the waves of water, into which a stone has been thrown. This simple comparison may give a moderately good idea of the manner in which sound radiates from a centre, but I cannot agree that it is applicable any further.

Again, it appears that in the earlier age of experimental philosophy, when dogmatical opinions were readily received with little examination, sound was considered to be so decidedly undulatory in its nature, that it supplied an argument by analogy that light was of a similar nature.

The undulatory motion of the segments of a goblet or a plate, and the waves produced on the surface of liquid placed

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on a vibrating body, give some weight to the supposition of undulatory motion of sound in its transmission. Sound is, however, transmitted directly from the vibrating body, but the appearances of wave motion produced are not in the direction of propagation, assumed in the undulatory theory of light; that is, that light is the result of motion of ætherial particles at right angles to the direction in which the light travels.

In all the instances in which we find undulations on the surface of a fluid, we shall also find that those undulations are the effect of gravity acting tangentially to the plane in which the undulation takes place. And I do not know any palpable instance of undulatory motion in which the influence of a tangential force cannot be perceived; as when a rope or a chain is made to undulate, the undulation is first induced by a force transverse to the direction in which the rope or chain is stretched. But we cannot discover any like transverse or tangential force necessary to the propagation of sound; and certainly we are without proof that any transverse motion does take place in the progression of a ray of sound. I therefore think we may, as regards our present knowledge of the nature of sound, reject every idea which would assume a motion more complicated than such a direct motion or series of impulses as will serve to explain the various observed phenomena.

In all the instances of vibration producing sound which can be submitted to observation, we may perceive that the motions of the vibrating body are such as to push away the surrounding air by a series of regular impulses, and that the particles of air might transmit such impulses through the surrounding particles, in like manner as the suspended line of marbles communicate impulses. And in examining the motions of the light powders on the vibrating plates, we find evidence of a direct motion of the air from the plate, but

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none of any transverse motion of the air; for the particles are raised by the current, and fall again by their gravity, without exhibiting any symptoms of transverse motion; for the motion of the air from the sides, to supply the place of that driven away, must not be considered as transverse or undulatory, for it is only a secondary current; and, indeed, its path, though curved, is not of an undulatory character. And I think the nature of the vibrations of columns of air (as in the organ pipe) gives some weight to the idea of direct impulse; for the pitch is dependant on the length of the pipe, and is affected by the diameter of the pipe in a very slight degree. But if the vibrations were of an undulatory nature, that is, vibrating from side to side of the pipe, it would be probable that by doubling the diameter of the pipe, or increasing its internal capacity four times, the tone should be two, or at least one octave lower. But doubling the diameter of an organ pipe does not lower the pitch more than increasing its length by about one-thirtieth part.

It, therefore, appears most probable that the production and transmission of sound is by direct impulses; but I think we ought to have a much greater weight of experimental evidence before we allow that more than a *primâ facie* case is made out.

The Rev. Dr. Scoresby conceived that the undulating theory of light was so well established, that it was assuming a bold position to attack it. The phenomena afforded by the Solar Spectrum and by Newton's Rings were affirmatory of the truth of this theory, and had been proved correct by a series of long mathematical investigations. The polarization of light added a further proof towards the fact.

After some discussion, Mr. W. S. Ward replied that he thought that a theory of light assuming its materiality and

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transmission by impulses might be proposed, which should afford similar data for calculation as the received undulatory theory; and that the results of mathematical investigation applied to such material or impulsive theory would also be satisfactory: also that he was of opinion that many of the effects of interference and polarization of light were phenomena of vision, leading to inferences much at variance with the undulatory theory.

Henry Hartop, Esq., then described "The Geology of the District of Wentworth," which paper will not be published at present, as the Author is desirous of extending his observations.

At the request of the Chairman, Dr. Heaton then read the following Paper:—

ON THE MUTUAL RELATIONS OF ANIMAL AND VEGETABLE EXISTENCE. BY J. D. HEATON, M.D., LEEDS.

My object in this paper will be to point out some of the various modes in which the continued existence and integrity of each of the great kingdoms of organized nature are made to be dependant upon the continuation of the same conditions on the part of the other. To show how the animal races of the present era are indebted to the agency of vegetable life in former geological epochs for the perfect adaptation of our atmosphere, and of the superficial strata of the solid globe, to their physical requirements; and how, by the mutual reactions, and counteractive influences of plants and animals, the atmosphere, the waters, and the more solid materials of the surface of our planet, are now retained permanently in a condition most exactly adapted to the necessities of both. Thus evincing most clearly that animal, vegetable, and

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mineral are all the results of the agency of *one* Mind, and *that* a Mind of benevolence and perfect wisdom.

It will be seen that for several of the facts and conclusions adduced in this paper, I am indebted to the writings of organic chemists of our own day; more particularly of Liebig, Dumas, and Boussingault, whose penetration and research have disclosed to us so many facts before hidden, relating to the more remote and intimate changes which take place in the performance of the functions of organised beings. Besides these, the views of botanists and physiologists of our own country have been likewise considered.

Our planet is, at the present day, surrounded by an atmosphere, of which the chemical composition is clearly ascertained; and a comparison of modern analysis with those of earlier chemists, prove that this chemical composition is fixed and permanent, being 79 parts of nitrogen, 21 of oxygen, and about $\frac{1}{100}$ part by measure of carbonic acid, in 100 parts.

But there are strong reasons to believe that at earlier periods in the geological history of our globe, the surrounding atmosphere was much more strongly impregnated with carbonic acid gas than at present. Such a condition of the atmosphere, though incompatible with the existence of the more highly developed and hot-blooded animals, would be favourable to a more rapid and luxuriant growth of plants than can be supported by an atmosphere having the composition of that which we now respire. Accordingly, we find in the coal which now forms so important an article of fuel, the evidence and the remains of so luxuriant a vegetation. "It was the conjecture of M. Brongniart, in the first instance from the study of fossil botany, and from other geological observations, that the atmosphere, at the time of primitive vegetation, was far more charged with carbonic acid than it is now, and that it was this which not only

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enabled gigantic species of plants to develope at a time when there was little soil to support them, but also, in some measure, prevented their dead remains becoming decomposed by the action of the oxygen of the atmosphere."* "It is further supposed," adds Dr. Lindley, "that the excess of carbonic acid thus assumed to have existed, which would have been fatal to air-breathing animals, was gradually abstracted from the atmosphere by plants, until the air became fit, in the first place, for the respiration of reptiles, and then for that of mammalia."

This latter particular is a most important one for our present consideration. It is a well-established fact in the physiology of plants, that the entire effect of vegetation upon the atmosphere is the removal of carbonic acid gas, which is absorbed by the green parts of plants into their tissues. Here the decomposition of the gas is effected, its carbon becoming fixed in combination with the elements of water, to form the constituents of freshly developing parts, whilst the pure oxygen is again discharged into the atmosphere.

Thus we can understand how the carbonic acid which loaded the atmosphere in a more early period in the history of our globe, was removed by the action of a luxuriant vegetation, which, having fixed the carbon in its own tissues, became itself converted into fossil coal; fitting the air for the respiration of man and other hot-blooded animals, and providing for him abundant stores of the most valuable fuel. The coal which we burn upon our hearths and in our furnaces, was formerly carbonic acid diffused through the air; and the effect of its combustion at the present day is, to restore it to the atmosphere again in the same state of gaseous combination.

Vegetation is still exerting the same influence upon the atmosphere as in former times, in proportion to its amount

* Lindley and Hutton's Fossil Flora, vol i., preface, page 21.

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and activity; but the composition of the atmosphere has remained unaltered since man has appeared upon the earth—probably since hot-blooded animals have peopled the surface of our globe. Animals, like plants, exert a marked influence upon the aërial medium in which they live, only this is of an exactly opposite nature to that exerted by vegetation. A portion of the oxygen drawn into the lungs of an animal at each inspiration is retained, and expiration discharges into the air, in its stead, an equal volume of carbonic acid gas. The removal of pure oxygen, and the substitution of carbonic acid, is the constant and invariable effect of all animal respiration. An animal confined in a limited portion of air soon deteriorates this so much by the process of respiration, that the air is incapable of any longer subserving this function, and the animal dies suffocated. It might be feared that the constant action of the whole animal kingdom upon the entire of our atmosphere, would in like manner so deteriorate the whole mass as to render it unfit for respiration, when all animal life must cease; but we have seen that vegetable life produces a precisely opposite effect, and by this mutual counteraction, an unvaried state of the air is constantly preserved during the present era of the world's history.

The infrequency of animal remains in the strata which represent that early period in the geological history of our earth to which we have before adverted, when our coal beds were living forests, leads to the conclusion that animals were as yet few in number; and they were chiefly aquatic or cold-blooded animals, whose slow respiration would be quite incapable of countervailing the effects upon the atmosphere of an active and crowded vegetation. Since that period, animal life is shown, in like manner, by the examination of fossil remains in the strata of more recent formation, to have been gradually on the increase in respect to numbers, and to have presented beings more highly organised, whose active respiration would more decidedly antagonise the effects of vegetable life; which

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effect has been likewise favoured by the diminution in the numbers and luxuriancy of the vegetable kingdom, as plants gradually exhausted the air of that stimulus to their growth, —the carbonic acid. "At length," says Liebig, "man appeared upon earth, and the air since then has been rendered constant in its composition."

From these considerations, it is evident that each of the great kingdoms of organized nature is mutually dependant upon the other for its continued existence. Had animals never been created, vegetation must in time have exhausted the air of carbonic acid, and plants must then have ceased to live. On the other hand, an animal kingdom alone would in time so diminish the amount of uncombined oxygen, and increase the amount of carbonic acid, as to render the air irrespirable, and all its species must die suffocated. Liebig says, "The presence of a rich and luxuriant vegetation may be conceived without the concurrence of animal life; but the existence of animals is undoubtedly dependant upon the life and development of plants." But it is evident that neither vegetation nor animal life could be permanent without the co-existence of the other.

It is proper, however, to state here, that Dumas and Boussingault have made a calculation, according to which it would require a period of 800,000 years for animal respiration entirely to convert all the free oxygen of our atmosphere into carbonic acid, supposing the counteracting effect of vegetation to be entirely arrested; and that it would only be after the lapse of 10,000 years, that the change produced in the atmosphere would become at all appreciable. From this it would appear that even had we not the benefit of the reducing action of vegetation upon carbonic acid, still, during the period over which the history of our own race extends, any change in the composition of the atmosphere would be quite inappreciable.

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But before we determine, upon these statements, quite to disregard this action of plants as unimportant and unworthy of notice, we must consider, in the first place, that the opposite effects of animal and of vegetable life are quite certain, and that the only question is one of time; viz., in what time would the action of either prove injurious if uncounteracted by the other. And likewise we must notice the great uncertainty and liability to error to which these calculations of MM. Dumas and Boussingault are liable. They estimate the population of our globe at 1,000,000,000 of men; and the entire animal creation at three times this number; then, knowing the effect of the respiration of a single man upon the oxygen of the air in a given time, it is easy to calculate the action of the entire animal creation, according to this computation, upon the total amount of oxygen in our air. But who can undertake to determine, with any show of probable correctness, at what sum the entire amount of the brute creation is to be estimated—quadrupeds and birds, and fishes and insects innumerable, on the earth, and under the earth, and in the waters? Moreover, even supposing the correctness of their calculations, we must remember that animal respiration is merely one amongst many other changes which are constantly going on in the material world, the effect of which is to cause the removal of uncombined oxygen, and the development of carbonic acid. The principal material, in the various substances made use of as fuel, is either carbon, or some compound containing a large proportion of this element; and its combustion consists in a rapid combination with oxygen, by which this gas is converted into the carbonic acid, attended with the development of an elevated temperature. When we consider to what a great extent the combustion of coal is constantly going on in a manufacturing country like this in which we live, (that is, how rapidly the carbon of the

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carbonic acid of the primeval atmosphere is being restored to that condition by artificial means, in the present day,) we must be convinced that this is an important item amongst the causes which remove oxygen from the air, and substitute carbonic acid. Besides this there are many processes constantly being carried on in the laboratory of nature, which produce one or other of these effects upon the atmosphere. Amongst those which are constantly introducing large volumes of carbonic acid, we may mention the active volcanos of the old and new world, more especially the latter. Amongst those causes by which oxygen is removed, we may mention the constant action of dead matters upon the oxygen of the air, this gas entering into combination with their elements. It is thus that metals rust, that rocks and buildings moulder away, that dead animal and vegetable substances decompose and putrefy, and that change and decay gradually invade all material substances, even the most durable. These are effects which we popularly attribute to *time*; but there is no *necessary* connection between the lapse of ages and the decay of material existences; this is due to the action of oxygen, and to other chemical and physical agencies constantly at work, but which, working slowly, require *time* to display their results; and if these were arrested, time would pass by innocuous. Or, to resume the metaphor, these are the *scythe* of time, armed with which his power is irresistible; but which taken out of his hands would be inoperative, and deprived of which he himself would become harmless.

It is no improbable conclusion, as we conceive, that all these agencies which we have enumerated, acting similarly upon the atmosphere, would (were they unopposed) produce in it an appreciable deterioration,* within a comparatively

* Were any change produced in the atmosphere by these causes, it would be permanent and constantly increasing; and though, for a short time, such a change might not be injurious to the health of animals, yet in the course of

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limited period; and the only counteractive influence, of the least moment, which is known to be in operation, is the action of vegetation.

But passing from the relations which exist between the plant and the animal, having a reference to their effects upon the air in which they reside, we must proceed to consider some of the phenomena of their *nutrition*.

As a general statement, there is one marked distinction between the materials for the nutrition of the beings belonging to these two great kingdoms of nature;—the plant can appropriate only such principles as are strictly inorganic; the food of the animal must consist of organized substances, or the organic principles derived from such. Any exceptions which might be made to this rule are quite unimportant for our present purpose;—thus, it may be said, that water and chloride of sodium, (common salt), and perhaps other salts, though quite inorganic, are strictly alimentary to the animal; and amongst plants, those which are parasitic, as the mistletoe or the dodder, derive supplies from the juices of the plants on which they grow, which contain organic principles; and the whole of the fungi are probably likewise an exception to the rule, and their action upon the air is likewise anomalous.

Passing by these limited and unimportant exceptions, the statement I have made is virtually correct. Animals, therefore, are incapable of adding to the total amount of existing organic matter; as they increase in size or numbers, it is only by appropriating to themselves matter already possessing the form of organic compounds. But by the

years, it might prove incompatible with health, or even destructive to life; and this, perhaps, before Chemistry could detect any departure from the previous condition. The endemic miasmata causing fever, and those more migratory derangements of the air, giving rise to epidemic diseases, are quite imperceptible by the most delicate chemical analysis.

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death and subsequent decomposition of their bodies, and by the constant removal, in various ways, of effete ejecta, matter which has previously existed in the state of organic compounds in animal bodies, is constantly being reduced to an inorganic state. Were it not the case, therefore, that the vegetable kingdom continually produces fresh supplies of organic compounds, animal life must gradually diminish and disappear. Directly, or indirectly, all animals derive their support from vegetable substances. Herbivorous animals convert their vegetable food into the materials of their own bodies; and these, in their turn, become the food of the rapacious carnivora.

The conversion of the flesh of one animal into the living body of another, by the digestive and assimilative processes, may seem to be a change simple and easily effected, the organic chemical principles of which both are composed being the same. But the conversion of vegetable substances in the bodies of herbivora, into their own tissues, has been generally supposed to require a greater change in the chemical composition of such aliments, and to imply a greater exercise of vital chemistry. Modern researches, however, in organic chemistry, (and more particularly by Liebig, who has added so much to our knowledge in this branch of the science,) have shown that those chemical principles, of which the tissues of animals are built up, are present in vegetable substances, though, in such, forming only a small proportion of the whole; but most abundant in those which are best adapted to serve as food for animals.

As this is one very important illustration of our subject,—showing how intimate and exact are the adaptations of one of the great kingdoms of organized beings to the requirements of the other,—I shall attempt a very brief outline of the facts bearing upon this point.

The principal chemical compounds containing nitrogen, or azote, of which the tissues of animals consist, are albumen,

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fibrine, and caseine; and these three principles have a strict chemical identity with what are found in vegetable substances, under the names respectively of vegetable albumen, gluten, (when in a pure state), and vegetable caseine. These are the principles which, though present in vegetable substances in but small proportion, are yet the most abundant in those which are best adapted as food for animals, and such as are most nutritious; for instance, in the grains of the various cerealia, peas, beans, &c.; and it is very interesting to observe, (as affording an evident instance of special adaptation,) that such substances likewise particularly abound in those earthy salts which enter into the composition of the bodies of animals, and form the chief part of the more solid organs of support—the bones, and which are, therefore, required to be present in their food. Other vegetable aliments, which contain much less of these azotized principles, (such as potatoes, turnips, carrots, clover, hay, &c.,) are less nutritious, and a larger amount is required to afford a satisfactory meal. Thus, a horse eats a much larger quantity of hay to satisfy its appetite than it would of oats, or other corn. But besides these azotized principles, animal bodies possess some chemical compounds which contain no nitrogen; such are the animal fats and gelatine; and by far the *greater* part of all *vegetable* growths consist of non-azotized principles; such are starch, gum, sugar, and vegetable fixed oils, which are much employed as aliment for man and other animals, (though less nutritious than the azotized principles previously mentioned,) and lignin, which is commonly not regarded as an alimentary principle.

With these facts before him, Liebig has been led to consider the converting powers of the digestive organs of herbivora, as being much more limited than has been supposed to be the case by former physiologists; and maintains that in the food of herbivora, it is only that amount of the azotized principles, identical with those in the tissues of

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animals, which is capable of sustaining the growth or continued integrity of such tissues; and that the non-azotized constituents of the food, may be capable of conversion into fat or gelatine, or may serve an important purpose connected with the function of respiration, and the maintenance of the elevated temperature of animal bodies, which will be afterwards explained,—or are, otherwise, merely excrementitious. This, however, seems to be a hasty and questionable conclusion. When we consider that carrots, turnips, and other esculent roots, and more especially the tubers of the potato, consist almost exclusively of non-azotized principles, together with small proportions of earthy salts,—that these are found to be decidedly nutritious,—and that the potato forms so important an article of food to the poor, particularly the Irish peasantry, who have muscles and sinews like other persons, and are not more remarkable for their fat than those who enjoy a more highly azotized food,—we shall perhaps be inclined to question the validity of Liebig's theoretical conclusion. It will also appear the more questionable, when we find a direct proof that animal bodies do possess a converting power over the materials of their food, by which an azotized principle is formed, differing from any present in the food. It is a remark of Pereira's* upon this point, that Liebig himself acknowledges that the chief constituent of nervous matter is a peculiar chemical principle, which is formed in the animal body exclusively, not being found in any vegetable substance, and which the purely herbivorous animal must, therefore, be constantly forming *de novo*. Urea, likewise, and other azotized excrementitious matters, must be constantly forming in the body, from the elements of effete particles previously having some other arrangement.

* Dr. Pereira on Food and Diet, p. 189.

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I shall only add, that there is no difficulty in suggesting probable sources from which nitrogen might be derived for combination with unazotized alimentary principles; and that, from all these considerations, there seems sufficient reason to believe, contrary to the opinion of Liebig, that the digestive and assimilative functions of herbivorous animals do possess a sufficient converting power to form muscular tissue, or other tissues composed of azotized principles, from non-azotized alimentary substances.

One important office is attributed by Liebig to non-azotized substances taken as food by animals, which was before alluded to, and which must now be briefly explained. This is its subserviency to the maintenance of the elevated temperature of the animal body, through the medium of the respiratory function.

This function consists essentially in the inhalation of oxygen gas into the lungs, from whence it is absorbed into the blood, where it enters into a chemical combination with portions of the carbon and hydrogen of some of the principles it there meets with, and is again discharged from the lungs as carbonic acid gas and watery vapour.

Whenever this combination of a combustible with oxygen is effected, it is accompanied with a development of caloric, more or less, according as the combination is more or less rapid and extensive; it is, in fact, *combustion*, and is of the same essential nature whether it take place with rapidity, as in the burning of fuel in our fire-places, or of gas in our lamps; or more slowly, as in a damp hay-stack, or by the process of animal respiration. To this action, constantly going on during the life of the animal, physiologists now attribute that elevated temperature which its body maintains during the same period.

The sources of the carbon and hydrogen employed in this function may be various; when food has been fully and

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regularly supplied to the animal, they may be partly derived from portions of this supply which have recently entered the blood from the digestive organs, and which have not yet become completely assimilated. When the animal has been stinted in its supply of food, or altogether deprived of this, the combustible elements to be consumed by this function of respiration must be derived from the materials of which the living body of the animal has consisted; and thus that emaciation be produced which is the known result of starvation, or an insufficient supply of food.

The non-azotized aliments, containing both these combustible elements, viz., carbon and hydrogen, are well adapted (independently of their directly nutritive properties) to subserve, indirectly, the nutritive function, by supplying some portion of the materials required for the function of respiration, and thus preventing a too rapid consumption of the tissues of the living body, by the oxygen which is inhaled at each breath; but it is not to be supposed that non-azotized food exclusively is subservient to this important office, which we have thus endeavoured to explain; but that, in this, all alimentary substances take a share; for all are rich in carbon and hydrogen, the important elements for this purpose.

In conclusion, I would remark that innumerable applications of vegetable substances, rendering them subservient to the comfort or luxury of animals, more particularly man, might be mentioned, but which are not dwelt upon here, as not being relations of that *essential* nature to which our present subject alone refers. Such, for instance, are the use of timber in the construction of our houses, or of vegetable drugs for the cure of our diseases. Had we no timber, we might substitute stone or metal; had we no vegetable drugs, we might depend upon mineral remedies or the unaided efforts of nature. But were

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animals deprived of all vegetable food, (to take an instance from the subjects we have treated,) mineral substances could afford them no support; and by feeding solely on each other, animal life would, (as we have seen,) be gradually exterminated; organized bodies would be constantly passing into the state of inorganic matter, without any provision for a fresh supply.

All, however, whether relations of necessity or merely of convenience, combine to illustrate the perfect adaptation of the various kingdoms of nature to each other, and the unity of design, the wisdom and the benevolence, which have presided over their creation.

THE EVENING MEETING.

The Chair was again taken by JOHN WATERHOUSE, Esq., when the following Paper was read

ON LIME AND ITS USES IN AGRICULTURE. BY HENRY BRIGGS, ESQ., OF OVERTON, NEAR WAKEFIELD.

It has been truly said, that what is called Earth or Soil is a most heterogeneous compound, and when analyzed is found to comprise matters of the most opposite characters,—neutralizing and combining with each other, when in due proportions, so as to form one harmonious whole. The first grand division which may be made in soils, is, into the *inorganic* and *organic* constituents, or such as have been derived from the disintegration of the rocks forming the crust of the earth, and such as have been produced from the decay of vegetable or animal matter. In most fertile soils the former (inorganic) constitute 95 per cent. or even more, of the whole bulk, leaving only five or less per cent. of organic or vegetable matter. The chief *inorganic* constituent of the soil is sand, forming in much fertile land

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even 8-10ths, or 80 per cent. of the whole. The next preponderating ingredient is alumina or clay, and after that comes Lime, a constituent of immense importance, and which I have chosen for the subject of the present paper. Lime, that is, pure Lime, is, chemically speaking, a compound of a metal called calcium, (which is enumerated amongst the simple or undecomposible substances,) and oxygen, (another of the simples or elements,) or in other words, it is an oxide of calcium—being composed of twenty parts of the metal to eight parts of oxygen. It has alkaline properties, and is capable of forming neutral Salts when combined with acids. It is slightly soluble in water, one pound requiring for solution seven hundred times its own weight of water. It has a great affinity for carbonic acid, and cannot be left for any length of time exposed to the atmosphere without thence imbibing that acid, by which its weight is nearly doubled, as they combine in the proportion of 55 of Lime to 45 of carbonic acid. It is then called Carbonate of Lime, and it is in this state that it is generally met with in nature. It is never, I believe, found in its caustic state, or in the form of *Quick Lime*, except sometimes in the craters of volcanoes, where the heat has dispelled the carbonic acid. The other forms in which it has been discovered to any extent are, as combined with sulphuric acid, forming Sulphate of Lime or Gypsum; and in some districts in conjunction with phosphoric acid, in the state of phosphate of Lime, which is the chief fertilizing ingredient of bones: but my observations will, on this occasion, be confined to its uncombined form as Quick Lime, and as a carbonate.

No doubt, all who are now present are aware that in order to convert Limestone, or in other words the carbonate, into Quick Lime, it is subjected to a red heat in a kiln for some days; by which the carbonic acid is driven off, and

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the stone loses nearly one half its weight. This carbonic acid, which is in a gaseous state, is the same as what is commonly called choke damp, and whose presence has so often proved fatal to parties descending into pits or wells that have not been properly ventilated. As an instance of its injurious effects, I may here mention that at a colliery in which I am engaged at Newton, near Castleford, where our pit is sunk through a thick stratum of Limestone, we have let the burning of Lime to a party who has now opened an extensive quarry, and in the course of his workings has excavated the stone within a few yards of some cottages. He formed one of his kilns against the side of the rock, (which is very open and full of seams,) next to the cottages, and during the progress of the burning, the dispelled carbonic acid found its way through the crevices into the cellar of the nearest cottage, which was excavated out of the same stone. The consequence was, that the wife of the inhabitant of the house, one morning, on descending into the cellar, was seized with giddiness, and had great difficulty in again ascending, when she fainted. Supposing that this was merely an accidental attack, and before the true cause was ascertained, a second and a third person were similarly affected. The kiln which had caused this catastrophe was afterwards speedily altered, so that the heated mass of stone should not come in contact with the face or side of the quarry, and all symptoms of choke damp were then removed.

Carbonate of Lime is found in many parts of England, in large quantities, and in different states of purity. Geologically considered, it is discovered to exist, more or less, in almost all the different strata of the Globe, whether consisting of the primary, secondary, or tertiary rocks, sometimes in seams of many yards in thickness, composed of little else but the carbonate, and at other times forming

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only a small per centage in the composition of the strata. The most pure Carbonate of Lime is the statuary marble, and the clear calcareous spars; but in the common form, as used for agriculture, and for cements, it is generally combined with an appreciable quantity of silex and alumina and often coloured by its containing a small portion of iron. Lime, when in the state of a carbonate, is insoluble in *pure* water, but if the water contain carbonic acid, (which is generally the case with that issuing from springs,) then it possesses the power of dissolving a small portion. It is, however, a curious circumstance, that this capability is greater at the common temperature of the atmosphere, than when of greater heat. This is the reason why sediment occurs in boilers in which water, holding carbonate of Lime in solution, is used, as the carbonic acid is dispelled by the heat, the absence of which incapacitates the water from any longer retaining the Lime. To shew a specimen of water containing Lime, I have brought a small quantity from a pump which we have on our premises at Overton, to which, if I add a few drops of oxalate of ammonia, (which is a delicate test of the presence of Lime,) you will observe an immediate precipitate.*

Lime is such an all-pervading substance in the different strata of the earth, that few springs are devoid of it, in one compound state or other, but generally as the carbonate, sulphate, or muriate. In the case of the Overton water it is the latter, (muriate), as the introduction of a little nitrate of silver will shew, which is the test for the presence of muriatic acid, and which will give the water a muddy bluish tinge, increasing in darkness by exposure to the atmosphere for a few minutes.† The Halifax water is, I believe, freer

* On the introduction of a solution of oxalate of ammonia, the water instantly gave a white precipitate.

† Here the addition of a few drops of a solution of nitrate of silver produced the effect mentioned.

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than almost any other in the kingdom from the compounds of this mineral, and hence its extreme and unusual softness—all water containing calcareous matter being hard.* Waters which hold in solution a considerable quantity of the compounds of Lime, are eminently adapted for irrigation, as by running over the grass, and exposure to the air, by which they lose part of the carbonic acid, they deposit a large portion of the calcareous matter which they previously contained in a state of solution, and which is extremely fertilizing: indeed, I believe it is an ascertained fact, that none of the neutral salts of Lime, hitherto discovered, are otherwise than fertilizing. I said that Limestone is found in England in both the primary, secondary, and tertiary rocks; but by far the greatest and most important supply is derived from the secondary strata; first from the chalk, then the oölitic series, next from what is called the Magnesian Limestone, and then from the mountain or Carboniferous Limestone. I have been able to obtain analyses of only three of these, namely, the Chalk, the Magnesian, and the Mountain Limestone, which I will proceed to detail; but I must, at the same time, acknowledge the source whence I derived them, which was from the report of a paper read before one of the sections of the British Association at York, by my friend, Mr. W. Lucas, of Sheffield.

ANALYSIS OF THE YORKSHIRE WOLD CHALK.

Carbonic Acid	43.00	Carbonate of Lime ...	98.42
Lime	55.42	Insoluble Matter	1.10
		Loss	0.48
			100.00

* Here some of the Halifax water was tested with oxalate of ammonia, and not the slightest presence of Lime was detected.

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MAGNESIAN LIMESTONE, SUBDIVIDED INTO KNOTTINGLEY LIMESTONE.

Commonly called the Magnesian Limestone.

Carbonic Acid	42.35	Carbonate of Lime ...	93.96
Lime	51.61	Do. Magnesia ...	Trace
		Red Oxide of Iron.....	1.42
		Insoluble Matter.....	4.50
		Loss.....	0.12
			100.00

WELDON LIMESTONE (THE REAL MAGNESIAN LIMESTONE.)

Carbonic Acid	46.00	Carbonate of Lime ...	62.12
Lime	35.04	Do. Magnesia ...	36.42
Magnesia.....	17.50	Red Oxide of Iron.....	0.90
		Insoluble Matter.....	0.50
		Loss.....	0.06
			100.00

MOUNTAIN, OR CARBONIFEROUS LIMESTONE.

Carbonic Acid	43.00	Carbonate of Lime ...	98.50
Lime...	55.50	Foreign Matter	1.50
			100.00

You will observe that the first and the last of these Limestones contain the greatest amount of pure Lime, and therefore, as far as that mineral is required, are of course the more valuable; but of what does the foreign matter consist in the other two? From an analysis made for me by Mr. Haywood, of Worksop, of the Knottingley and Weldon Lime, the foreign matter was found partly to consist of a phosphate, and potash combined with silica, as follows:—

	Knottingley.	Weldon.
Phosphate.....	.087	.100
Potash combined with Silica ...	.128	.196
	.215	.296

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Both of which ingredients are highly fertilizing. Whether the insoluble matter mentioned by Mr. Lucas, in the Chalk and Mountain Limestone, consists of the same ingredients and in the same proportion, I am not aware, but it is more probable that it is so than otherwise. The red oxide of iron, existing in the Knottingley and Weldon stone, being in the state of a *Peroxide*, would also tend to fertilize. I may here remark that the term *Magnesian*, as applied to *all* the Limestone coming to the surface between Castleford and Knottingley, appears to me to be a *misnomer;* as there are two separate and distinct strata in that district, divided by a seam, some yards in thickness, of red clay, interlaid with beds of gypsum. The upper stratum is thinly laminated, and contains only a trace of carbonate of magnesia, while the lower is in thick beds or blocks, and contains from 30 to 40 per cent. of that substance. In the geological maps I therefore conceive that these two strata ought to be more distinctively marked.

But to revert to the more immediate object of this paper—"The uses of Lime in Agriculture." The celebrated chemist, Sprengel, says, "A soil is often neither too heavy nor too light, neither too wet nor too dry, neither too fine nor too coarse: lies neither too high nor too low,—is situate in a propitious climate,—is found to consist of a well-proportioned mixture of clayey and sandy particles,—contains an average quantity of vegetable matter, and has the benefit of a warm aspect and favouring slope: it has all the advantages, in short, which physical condition of climate can give it, and yet it is unproductive—and why? Because, answers chemical analysis, it is destitute of certain mineral constituents which plants require for their daily food." One of the most important of these mineral constituents is Lime. No commonly cultivated vegetable that has yet been analyzed, has been found entirely devoid of

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this ingredient; and we may therefore, I think, reasonably conclude that it is an essential, in order to produce a properly developed plant; in fact, that it is one of the substances which constitute its necessary food, and help to build up its frame. To insist upon growing plants, into whose structure Lime largely enters, upon land devoid of that esssential, is something similar to the conduct of the mother that I lately heard of, who, when her child was about forming its teeth, in order to give it strength, fed it entirely upon arrow root, supposing *that* diet to be the most nourishing. Now arrow root contains only the elements of *fat*, and not of *bone* and *muscle*. It affords no phosphoric acid and Lime. The child therefore continued ricketty, and could form neither bone nor teeth. Immediately that the diet was changed, and food containing those necessary ingredients was administered, the desired result took place, and the child soon became strong and healthy.

According to Professor Johnston, a common four-years rotation of crops, that is—Turnips—Barley—Clover and Wheat—extracts from the land, and consequently there requires to be supplied, during the four years, 288 pounds of pure Quick Lime, or about 524 pounds of the Carbonate —the turnips and the clover, or the two green crops, needing at least 9-10ths of the whole. Viewing Lime, then, as one of the essential constituents of plants, we must acknowledge the necessity of its presence in the soil, even if its being food for the crop, only, were taken into account, without considering its other uses, which I shall shortly touch upon. Hence we also see how essential is its artificial introduction into the soil, where it does not already naturally exist in sufficient quantity. Sir Humphrey Davy, in his Agricultural Chemistry, enumerates many fertile soils, of which he gives the analysis, and in none,

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I believe, did he find less than three per cent. of carbonate of Lime, and one contained as much as 11 and 1-4th per cent. In a soil of eight inches in depth, three per cent. I calculate, would amount to about 32 tons per acre, which at the rate of exhaustion by the crop alone, as computed by Professor Johnston, but without taking into account any other sources of waste, would last about 130 rotations, or about 500 years. But as much of the straw and turnips are again returned to the land in the shape of manure, which contains part of the Lime previously extracted, such land might probably not be exhausted of that ingredient (at least by the crops) for three times that period. Much land, not situated near the Limestone districts, I believe contains as little as only 1-10th per cent., or only about 22 cwt. per acre; and that is the description of soil which most frequently wants replenishing; as, if you compute the exhaustion from all causes to amount to ½ cwt. per acre per annum, (which in the common course of cropping I believe to be pretty near the mark,) all the stock of Lime will be extracted in about fifteen years, provided that none is returned in any shape. Professor Johnston in his lectures mentions, that Lampadius tried an experiment in order to test the amount of exhaustion of Lime, stating that he mingled Lime with the soil of a piece of ground till it was in the proportion of 1.19 per cent. of the whole, and he determined subsequently, by analysis, the quantity of Lime contained in each of the three succeeding years.

		Carbonate of Lime.
The 1st Year it contained		..... 1.19 per cent.
2nd	do.	..... 0.89
3rd	do.	..... 0.52
4th	do.	.... 0.24

But what are the sources of exhaustion beyond what is extracted by the crops? The chief, no doubt, is from the

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solubility of the Lime, when it comes in contact with water containing carbonic acid, and in which state of solution it is carried into the substrata, and finally brought to the surface again by the springs; after which it is again deposited on the land in another locality, or carried by the rivers into that great receptable, the sea, where, as nothing in nature is lost, it is again appropriated by those occupants of the deep, whose covering and habitations are formed from calcareous matter. When we consider the immense quantity of rain that in England annually falls upon the earth, being on the average equal to about thirty inches in depth, which will amount to about 668,000 gallons per acre: and that it always contains an appreciable quantity of carbonic acid, rendering it capable of dissolving Carbonate of Lime, we need no longer be surprised that that necessary ingredient so quickly disappears from the soil, and requires renewing.

Again, it is an often-observed fact, that Lime sinks into the soil, without being actually brought into solution, and is lodged below the reach of the spade or the plough, or of the plants that we wish to cultivate.

Lime may be effectively applied to land in different states;—either in its real quick unslaked state, as it comes from the kiln, (when it is the most caustic,) or when slaked with water, in which state it is called Hydrate of Lime, and still caustic;—or when it has fallen to a powder by mere exposure to the air, and is only partially caustic; or it may be applied in the state of a carbonate, when it has lost all its causticity. In its two first states it ought not to be applied to such growing plants as you wish to preserve, as it is then injurious to vegetable life, and should therefore be put upon the land only when under the plough, or some days previous to sowing the seed. The circumstance of its being fatal to vegetable

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life, when in this highly caustic state, is at the same time extremely useful to the agriculturist, in assisting to destroy not only noxious weeds, but in ridding the soil of the larvæ and eggs of various destructive insects, which would otherwise prey upon the crop.

But perhaps its most important office, as Quick Lime, is to release the potash, locked up, as it were, in the soil, by rendering it soluble, and indirectly acting upon the silica, so necessary for the healthy and luxuriant growth of the cereal plants. Liebig, in treating upon this subject, says—"In order to form a proper conception of the action of Lime on soils, we must remember the processes employed by chemists to effect the speedy decomposition of a mineral, and to render soluble its ingredients. In order to dissolve finely pulverised felspar in an acid, it would be necessary to expose it to continued digestion for weeks, or even months. But when the felspar is mixed with Lime, and is exposed to a moderately strong heat, the Lime enters into chemical combination with the constituents of the felspar. A part of the alkali (potash) imprisoned in the felspar is now set at liberty, and its simple treatment with acid, in the cold, now suffices to dissolve the Lime, and other constituents of the mineral. The silica is dissolved by the acid to such an extent, that the whole assumes the consistence of a transparent jelly. Most of the silicates of alumina, when mixed with Slaked Lime, and kept in continued contact in a moist state, behave in a similar manner to felspar when heated with Lime. When a mixture of common clay and water is added to the milk of Lime, and they are left in contact for several months, it is found that the mixture gelatinizes on the addition of an acid. The clay is broken up by the union of certain of its constituents with Lime, and most of the alkalis contained in it are set at liberty. These experiments have explained the action

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of Slaked Lime upon soils, and have furnished an invaluable means of liberating from the soil the alkalis which are indispensable to the existence of plants." Again he says—"It is obvious that mixtures of clay and Lime contain all the conditions necessary for the liberation of the silicate of alumina, and for rendering soluble the alkaline silicates." Dr. Playfair also says that "by Liming the land, the silica, potash, and phosphates are liberated from the soil, and administer to the wants of vegetation." Professor Johnston also holds the same opinion, and says, "potash and soda exist to some extent in clay soils in combination with alumina—the presence of Lime has an influence in setting the alkalis free from this state of combination." Supposing, then, that the opinions of these celebrated chemists are correct, it fully explains, to my mind, why it is so frequently maintained, that the repeated application of Lime deteriorates the fertility of land. That such is the effect of a *large* and *frequent* application, I have not the least doubt; and it can be accounted for by the circumstance of each such dose rendering soluble a greater quantity of the potash, silicates and phosphates, than the plant can possibly take up; the surplus in a state of solution, is therefore carried away by the rains and lost; and the accumulated stock at last exhausted. It appears to me, that according to this view, a small quantity only of Quick Lime, frequently repeated, would be the most economical, and at the same time, effective; suppose, half a ton every other year, or a quarter of a ton every year, when practicable, or a somewhat larger quantity only when you have a crop which, according to the analytic tables, requires a larger supply of potash—but of course you must first ascertain whether your soil contains a supply of the alkalis, ready to be released. In some of our land at Flockton, according to a minute

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analysis which we have obtained, there exists as much as six tons of potash per acre, six inches deep, a supply which, with proper husbanding, will last for 600 years, without any further artificial application. The province of the silicates, in their effects upon the grain crops, is to render the straw more stiff and healthy, and to give it strength properly to sustain the ear. They communicate that peculiar polish or varnish which is observable on the exterior of healthy straw, and which prevents the corn from being lodged or laid by rain and wind. As an instance of the good effects of Lime, and to prove the correctness of the theory of its action in releasing the silicates, I may mention a circumstance which a few months ago came to my knowledge, where one half of a field of wheat was Limed, and the other not. The corn on the former grew with a strong stiff and upright straw, and a good ear;—while on the latter, where no Lime was applied, though the ear was also good, yet the straw had not power and strength sufficient to support it, and the crop was spoiled by being laid. Quick or Calcined Lime also produces the beneficial effect of rendering available any inert vegetable matter that may be in the soil, by assisting its decomposition, when it has access also to the air, and thereby renders it food for the plant, and at the same time enters into combination with the acids that are formed in the course of decomposition,—acids which would otherwise be injurious to the growing crop; and some of the compounds thus produced, are considerably more soluble and deliquescent than the Lime was in its original state.

It is an interesting question, whether, as silica is so necessary a constituent of the corn crops, and is insoluble except through the intervention of a caustic alkali, Quick Lime being an alkaline earth, has *immediately* that effect?

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I should fear that as the Lime has so strong an affinity for carbonic and other acids, which it might meet with in the soil, it would become so quickly neutralized, that it could not remain in its caustic state sufficiently long in contact with the silica of the soil, to enter into combination with it. A silicate of soda may, I believe, be manufactured artificially, by making a compost, intimately mixed, of equal parts of carbonate of soda, Quick Lime, and fine sand, and excluding the free admission of air to the heap.

The Lime having a greater affinity for carbonic acid than the soda, extracts and appropriates the acid, leaving the soda caustic, in which state, in the course of a few weeks, it combines with the silica of the sand, and forms the compound spoken of, in a soluble state. In many districts sulphuret of iron is one of the injurious compounds that are found in the soil, and by exposure to the air and moisture, it is converted into the sulphate, in which state it is doubly baneful to vegetation. The application of Quick Lime soon decomposes this deleterious compound, and forms gypsum and peroxide of iron, both of which are fertilizing.

Sulphate of Iron. { Iron ——— combines with Oxygen forming Peroxide of Iron.
Sulphuric Acid

Quick Lime ——————————— Sulphate of Lime.

Quick Lime also prevents the red rust in wheat, which, according to Mr. Haywood's examination, is caused by the plant imbibing phosphate of iron, which compound the Lime decomposes, and then forms phosphate of Lime, being the main fertilising part of bones. It is frequently affirmed that if you form a compost of Quick Lime and muriate of soda or common salt, a decomposition and recombination takes place; that the muriatic acid leaves the salt and combines with the Lime, forming muriate of Lime and caustic soda.

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But this I cannot conceive to be the case, as it is contrary to the order of affinities, the acid having a greater affection for the soda than for the Lime. Professor Graham, whom I had lately the pleasure of meeting in London, informed me that if the compound be kept in the state of a paste for some time, and then dried, there certainly is a sublimation of carbonate of soda, but only in a trifling degree. The two substances are good in themselves, and might be applied with equal effect separately. When applied to clover leys previous to being ploughed up for wheat, both seem to answer the desired purpose, in destroying the wire worm or other ravaging insects; as may be shown by an experiment which we lately tried, where on one part of a field we laid five cwt. of salt per acre, at a cost of 6s., on another we put one ton of Quick Lime per acre, at a cost of 10s. 6d.; and on the third we did not apply anything: the wheat was equally good on the two portions treated with salt and with Lime, but on the other, where nothing was applied, the crop failed so grievously that we had to sow it over again.

Lime is extremely congenial to clover, and I believe that if one ton per acre of that fertilizer were applied, along with half a hundredweight of nitrate of potash, common salt and gypsum, (half a hundredweight of each,) the failure of the clover crop so frequently complained of, would only occasionally occur, and that chiefly from the injurious effect of frost; for I cannot but consider that the failure arises in most cases from a deficiency in the soil of proper and quickly available food for the plant,—clover requiring a considerable quantity of Lime, potash, soda, and sulphuric acid. I have frequently observed instances on the moors in Craven, where, after the plentiful application of Quick and Caustic Lime, in the course of a few months the heath has all disappeared, and a luxuriant

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crop of white clover has afterwards occupied its place. On grass land the Lime ought to be applied in a partially effete or mild state, otherwise it will injure the vegetation. Quick Lime should not be applied simultaneously, or mixed with any manure containing the salts of ammonia; for it has so much greater an affinity for the acids than ammonia, that immediately on their coming in contact, the ammonia is set at liberty and dispelled. The application of Lime to land ought, therefore, to be ten days or a fortnight previous to the manure being introduced, by which time the Lime, if well spread and harrowed into the soil, will have become sufficiently a carbonate not to affect the ammonia. From the foregoing considerations, and from an analysis of common yellow clay made for us by Mr. Haywood, by which he found that one ton of clay contained fourteen pounds of caustic potash, and an appreciable quantity of phosphoric acid, I imagine that Unslaked Lime, as it comes from the kiln, and clay, laid up, layer upon layer, would form a good compost, particularly for the lighter soils. My observations have hitherto been mainly confined to the action of Lime when in its quick state—in which only it is thought by many farmers to be effective and valuable. But this is quite a mistaken notion:—its virtues last for years, and continue so long as any remains in the land. In the caustic state it renders other things into manure, and after it has accomplished that object, it becomes itself food for the plant. As the Carbonate, or Mild Lime (which state it shortly assumes after its application), it renders the corn crops better and finer in the skin—causes them to come earlier to maturity—corrects acidities and impurities in the soil, thereby sweetening the herbage—is a great absorbent of moisture—and has not only a chemical, but also a mechanical effect upon the soil, by lightening that which is too stiff, and stiffening that which is too light; in fact the value and virtues of Lime are not yet sufficiently and extensively known.

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An instance of the injurious effects of a deficiency of Lime, is cited by a writer in the last number of the Quarterly Journal of Agriculture, where he says that during the late dry summer he observed that many of the grass fields in the neighbourhood of Liverpool were covered with sorrel, being quite red with that sour plant in seed. On chemically examining the soil, he found that it contained an excess of humic acid, and a deficiency of Lime. An application of the latter would have neutralized the bad effects of the former, and rendered the land incapable of luxuriantly producing so acid a plant as sorrel, which would have given place to clover and other sweet herbage. Sir John Sinclair mentions, that on the Mendip Hills, in Somersetshire, by the application of Lime, the value of land was raised from 4s. to 30s. per acre; and dung, which previous to Liming had no sensible effect, afterwards operated as on other soils; and the rye lands in Herefordshire, which formerly refused to produce wheat, peas, or vetches, have, since the introduction of Lime, been so fertilized by its application, as to render the soil capable of producing every species of corn.

In the former part of this paper I mentioned that there is found another description of Lime in the neighbourhood of Castleford, and also at Conisbro', near Doncaster, which may truly be designated by the term *Magnesian*, as it contains from 30 to 40 per cent. of carbonate of magnesia. This sort of Lime has been found to be injurious to land for some time after its application in the quick state, except when very sparingly used; and the reason is, that the magnesia which it contains is so long in imbibing sufficient carbonic acid to neutralize its causticity, that it burns up, as it were, all growing vegetables with which it comes in contact. The real and pure Lime which this stone contains has a greater affinity for carbonic acid than the magnesia, and *it*, therefore, first appropriates all the attainable acid, until it is satisfied, before the magnesia obtains any, during

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which time the latter remains in its caustic state. To peaty soil containing much carbonic acid, the Magnesian Lime may be effectively applied.

I said that carbonate of Lime is an absorbent of moisture. Sir Humphrey Davy mentions, that in continued dry weather in Derbyshire, while the hill sides resting upon grit stone are burnt up, the vegetation on those where the substratum is Limestone, appears green and luxuriant. I have also heard of a gentleman who, in order to obtain and preserve a green luxuriant appearance on his lawn, which was previously quite brown in dry weather, pared the sod, and inserted under it a layer of Limestone, after which the desired result took place. In the *Quarterly Journal of Agriculture*, I observe a paper by Mr. Glyde, in the course of which he gives a table of the powers of absorption of moisture by some of the constituents of soil, which will explain why vegetation growing in land resting upon a subsoil composed of Magnesian Limestone, should not be so greatly affected by dry weather.

The following Table shows the powers of absorption of moisture, possessed by different ingredients of soils. 1000 grains of each, spread over a space of 56 inches, the temperature of the air being 60 degrees, time of exposure being 72 hours.

Silicious Sand	0
Calcareous Sand	3
Gypsum	1
Sandy Clay	28
Loamy Clay	35
Stiff Clay	41
Grey pure Clay	49
Lime	35
Magnesia	82

In conclusion, I beg to express an opinion that perhaps the agriculture of no locality would be more improved by

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the application of Lime, than the neighbourhood of Halifax —the extreme softness of the water being, I think, a sufficient proof that the soil is very deficient in that necessary ingredient; and I should strongly recommend any one who owns or cultivates land in that neighbourhood, to have his soil analysed, to ascertain whether it is so situated.

The district between the Summit Tunnel and Manchester, on the Manchester and Leeds Railway, also appears to me as another part of the country which would be amazingly improved in fertility by the application of Lime; as, from the appearance of the land and its produce, and the great quantity of ferruginous water which exudes, to the serious detriment of vegetation, I imagine that Lime is much needed to correct the acidities, and neutralize the injurious salts of iron that are so profusely generated.

Should any one receive the least useful hint from these remarks, (which have been hastily collected and thrown together,) that may induce him to pursue inquiry into the secret uses and workings of the various means that we possess, of adding to the resources of our country,—my object in bringing forward the subject will be amply answered.

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE TWENTY-NINTH QUARTERLY MEETING, HELD IN THE TOWN HALL, PONTEFRACT, ON FRIDAY, AUGUST 8TH, 1845.

The Right Hon. the Earl FITZWILLIAM in the chair.

On the motion of the SECRETARY, the following gentlemen were elected Members of the Society:—

Rev. ANDREW CASSELS, Morley.
Lord GALWAY, Serlby, near Bawtry.
Rev. T. HIND, Featherstone, Pontefract.
SAMUEL HIRST, Esq., Kellington, Pontefract.
WILLIAM HEPWORTH, Esq., Pontefract.
RICHARD MONCKTON MILNES, Esq., M.P., Frystone.
Mr. MOXON, Pontefract.
Rev. RICHARD STAINFORTH, Pontefract.
Dr. SIMPSON, Pontefract.

His LORDSHIP rose and said, that the Society with which they were connected had frequently met in different towns in the West Riding; and now they were assembled in that town which, in one respect at least, might be considered as a sort of metropolis—it being that town in which the principal magisterial business was transacted. It was always a satisfaction to visit a town where hospitality was shown to strangers; and it was a great satisfaction to him to be able to meet his fellow-associates in the fulfilment of their labours, in a town where they were most admirably accommodated by the liberal hospitality of the worthy Chief Magistrate of the borough.

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It was with great satisfaction that he had to announce that some very interesting communications would be made, for the first of which they would be indebted to Professor Phillips, who would now proceed with his communication.

Professor PHILLIPS, of St. Mary's Lodge, York, then read his paper

ON THE REMAINS OF MICROSCOPIC ANIMALS IN THE ROCKS OF YORKSHIRE. BY JOHN PHILLIPS, ESQ., F.R.S., F.G.S.

There is nothing more certainly proved, more generally known, or more important in Geological reasoning, than the fact that a very considerable portion of the stratified masses of the globe is composed of the remains of organized beings. Changed vegetables have yielded our coal—changed Zoophyta compose the entire mass of some limestones—shells contribute to augment the thickness of almost all the strata which rest upon the Gneiss and Mica schist groups.

It is also known, that, in very many instances, plants and Zoophyta occur in a fossil state, on the very spots where they were attached in life; that they did actually grow and perish where now we find their remains. Shells in like manner appear with all the marks of being entombed on or near to the very localities where their molluscous tenants respired and fed; the valves of oysters are yet attached to the rock, stone, or old shell on which the young ova fixed themselves; lithodomous Conchifers yet occupy the very holes which they have bored; Cardiacea and Veneridæ yet display their valves, as closed by the muscles in life, or partially opened by the decay of these muscles, or separated by the decay of the ligament, or finally broken and worn by the agitation of the water in which they died.

It follows, from investigations of this kind, that in the same physical area of the earth's surface, but at successive

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times, different races of plants and animals lived, whose specific forms changed with those successive times, and being preserved to us, are characteristic or indicative of these times.

It also follows that the chemical processes which are necessarily coincident with the phenomena of life,—the decomposition of the carbonic acid of the atmosphere by respiration of plants,—the decomposition of sea water by marine plants and marine animals,—the secretion of solid carbonate of lime and pure silica in the substance of shells, corals, and sponges, must have continued through times and under conditions equal to produce the amount of those effects which Geology has measured and made known.

These things are generally known and admitted; but it is possible by scrutinizing more minutely the texture of rocks, to extend the data and fortify the reasoning. Our *admiration* of the degree in which the hard parts of animals have contributed to augment the so-called mineral masses of the globe will indeed rise to *astonishment*, if we call to our aid the magical power of the achromatic microscope, and investigate with it the ultimate constitution of the limestones, flints, sands, and clays, in which the unassisted eye sees nothing but a mere aggregate of earthy particles.

We may effect this in at least four ways;—1st, by cutting stones into thin slices, so that they become transparent; 2ndly, by incineration; 3rdly, by pulverizing and washing softer substances, such as chalk; and 4thly, by distilling chemically some parts of a rock, and leaving others for examination in a finely divided state.

This investigation has drawn forth a crowd of observers, of whom Ehrenberg is the chief. It results from their inquiries, that in the *superficial deposits* of Geology, which are scarcely counted among the old stratified masses, but belong to comparatively recent periods, vast numbers of

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minute organisms occur, so that whole lakes have been filled up by them, and deposits, composed of little else than the remains of infusorial animalcula, have been measured to as much as 14 feet in thickness.*

Further, that in the genuine *Tertiary Strata*, as, for example, the Eocene Sands of Grignon, the proportion of minute Foraminifera, which is mixed with the common sand, is enormous.†

Again, that in secondary strata, especially in the *chalk*, minute Foraminifera and minute Infusoria abound, so that whole beds appear to consist of little else, especially in the South of England and in the North of Germany.‡

It has been also ascertained, that in the secondary strata below the chalk, particularly in the Oölites of Yorkshire and Stonesfield, many of the Foraminifera occur; and it is a result of my own researches, that in the mountain limestone they are not rare, and that the limestone of South Devon and the silurian limestones contain traces of this widely diffused class of Microzoa.

I will now briefly notice, commencing with the Mountain Limestone, the most frequent of the minute organized bodies, which are revealed by the microscope, in those parts of the calcareous deposits of Yorkshire, which, to the unassisted eye, appear to be devoid of organization.

Of this rock it will be sufficient to notice two varieties, the oölitic and the compact. In the former it is common to find, in the centre of the grains or ova, minute Foraminifera, bits of coral, small joints of Encrinites, and small Goniatites.

In the compact rock we find precisely the same things, as Foraminifera, small Milleporidæ, minute Cyathophylla, minute Calamoporæ, Crinoidal joints, and Goniatites. They

* Ehrenberg. † D'Orbigny, &c. ‡ Ehrenberg. Reade. Mantell.

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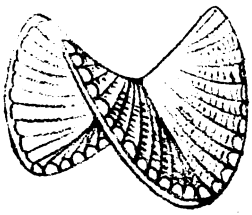

FIG 8

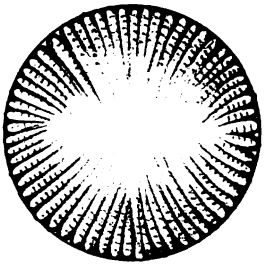

FIG 9

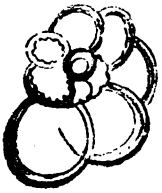

FIG 7

FIG 6

FIG 5

FIG 3

FIG 4

FIG 1

FIG 2

J F MASSEB LITH LEEDS

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are by no means equally diffused. In the brown clouded marbles of Beetham Fell, they are so very plentiful as to crowd the field of the microscope. Similar characters belong to the white Mountain Limestones of Russia.*

Amongst these fossils I distinguish a beautiful concamerated shell, most probably a Foraminifer, with a large opening in each septum, on the interior edge. Formerly I saw in the possession of Mr. John E. Bowman a specimen of this kind, visible to the naked eye, and named it Endothyra Bowmanni. *(See Fig. 1.)* The volutions are swollen externally between the septa.

Another common form of Foraminifera is represented in section in *Fig.* 2.

Beside these, are many minute spiral shells of Gasteropoda.

In the Magnesian Limestone, as yet, I have been comparatively unsuccessful. The compact parts of the rock seem to consist of earthy grains, imbedded in a cement of crystalline carbonate of lime; and this is a very general character of the so-called earthy limestones. Similar characters belong to the Magnesian (Permian) Limestone of Russia.

The Nodular Lias beds of Yorkshire I have not yet examined. The blue Lias of the South of England is in some beds rich in portions of Crinoidea, but in others almost devoid of organization. Small Conchifera appear in the sections, but I have not observed Foraminifera. There are in this stone some singular patches, (green, by transmitted light,) which I am as yet unable to resolve.

The whole Lias of the vicinity of Bath is a mass of minute granulation, cemented by a carbonate of lime. There are many little concentric textures, with a dark centre.

* I am indebted to Sir R. I. Murchison for specimens of the Palæozoic Limestones of Russia. They have furnished many interesting facts under the microscope.

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Some beds of the Oölite of Yorkshire are remarkably rich in minute organization. Abstracting the consideration of the oviform grains, which in this rock are somewhat different from the ova in the Bath Oölite, we find minute spines of Echini, bits of shell, and plenty of small Foraminifera. These latter are in fact numerous, and generally of the form of Textilaria. Within a circle of 1-40th of an inch in diameter, we frequently find three of these beautiful shells, the lamina which discloses them being less than 1-200th of an inch thick. This would give, in one cubic inch, 960,000 individuals, or one million wanting 40,000. I have seen but few Rotaliæ in this Oölite.

Fig. 3 represents a beautiful section of one of the discoid or Nautiloid Foraminifera, parallel to, but not quite through, the axis; the enclosing calcareous paste is there. The transverse fibres, of which the shell consists, are visible.

Fig. 4 is a minute spiral shell of a Gasteropod, (Turbo), enclosed in a thin calcareous paste.

Fig. 5. A portion of a species of Cidaris, enclosed in an oval grain, which is formed of concentric sheaths of radiating fibres.

Fig. 6. A finger joint of an Encrinite, enclosed in a grain of opaque granular calcareous paste, in which neither concentric sheaths nor radiating fibres are distinct.

The Oölitic grains are separately suspended, so to speak, in a connected mass of clear crystallized carbonate of lime; and this circumstance is almost universally recognised in the Oölites of the North of England. The Oölite of Ketton, in Northamptonshire, is, in this respect, very different, being mostly an aggregation of round grains in contact.

In the chalk of Yorkshire occur, but far less frequently than in that of Kent and Germany, minute Foraminifera, especially of the genera Rotalia and Textilaria. I have rarely found in it the spicula of sponges, or the minute coralloidal bodies which are mentioned elsewhere.

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The Yorkshire chalk is not so well suited for microscopic examination as that of the South of England, nor are the flints which abound in it so rich in organization as those of Kent and Wiltshire. They appear, however, to contain, though in less abundance, the same minute organizations. Flint, with a peculiar cloudy, mottled, textural arrangement, which Mr. Bowerbank refers to sponge, contains imbedded in its substance several kinds of minute structures, of which the so-called Xanthidia are the most remarkable. In general, I find in the chalk and flint a quantity of organization, continually increasing in proportion to the clearness and perfection of the microscope. Not a small part of the mere powder-grains are single cells of the Rotalia and Textilaria. (See *Fig.* 7 for the outline of a Rotalia.)*

Among the numerous lacustrine deposits on the coast of Yorkshire, of which 16 years ago I published the descriptions, one has often since attracted my attention, from the great probability of its containing Infusorial animalcula. I allude to the peculiar white and brown cretaceous marly deposits, a quarter of a mile north of Bridlington. I have often examined this marly substance, but my instrumental means, till within a few years, were inadequate to the research. The Rev. W. V. Harcourt found it to contain a certain proportion of silica. I have repeated this experiment, and find among the siliceous grains left by the action of dilute acid, a considerable number of Loricated Infusoria, chiefly of the genera Navicula, Cocconema, Bacillaria, and Eunotia. I have also been fortunate enough to discover a new species of the rare genus Campilodiscus in this marl; and as occurrences of this kind are not frequent in England, and as no fossil Infusoria have been

* Dr. Mantell has found in the substance of flint not only the shells but the animal substance of Rotaliæ.

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as yet even mentioned in Yorkshire, I have drawn up a short catalogue of the contents of the deposit, as far as I have yet traced them.

In the Bridlington Deposit occur :—

Foraminifera...	1. Rotalia.....	Probably derived by watery action from the adjoining chalk.
	2. Textilaria...	
Infusoria.		
Pyxidicula ?		
Gaillonella varians		Also at Bann, Ireland.
Navicula phœnicenteron.		„ „
„ inequalis		„ „
„ viridis.....		„ „
„ gibba		„ „
„ indeterminate.....		At Berlin.
Cocconema lanceolata		At San Fiora.
Bacillaria vulgaris		„
Campilodiscus zonalis *.....		„
Eunotia diadema.....		„
„ serra		At San Fiora and in Hanover.
Synedra ulna		Also in the Polierschiefer.

Fig. 8 represents the Campilodiscus zonalis, found fully inflected, as some of the specimens of Campilodiscus clypeus occur at Egra. *Fig.* 9 shows its expanded discoid aspect, when the inflection is slight, but easily made evident by a proper management of the microscope. The radii (if they may be so called) are symmetrical to two axes, which may be compared to the equator and a central meridian, in the common projection of the sphere, the seeming radii being slightly comparable to the terminal parts of the arcs of latitude in this projection. In very favourable lights, concentric striations may be detected crossing these ribs, and there is some appearance of punctation on the outer edge. In other cases, the ribs seem nearly smooth or delicately punctated. This may arise from the different character

* See *Figs.* 8 and 9.

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of the two discoid faces. These specimens are rare, even in fragments.

The Infusorial remains are by no means equally diffused through the marl. On some occasions I have sought whole days in vain for any interesting forms, but sometimes a small fragment of marl has yielded me a good supply. They are, however, never so plentiful as in many of the localities in Italy, Germany, Hanover, Sweden, and North America. The deposits of San Fiora, in Tuscany, and Hanover, seem to yield nearly all the species of Bridlington; and in *Charlesworth's Magazine* for 1839, and in a drawing in the possession of Dr. Mantell, many of the same Infusoria are noticed from Bann, in the county of Down, in Ireland.

As it thus appears from all the investigations, that there are two tribes in particular which have left their minute remains in such abundance, through a large series of rocks, as to have been rather boldly regarded as the real constituent molecules of them, I shall add a short summary of their more remarkable natural characters, as determined by examination of living and fossil specimens.

1. The Foraminifera consist of an external shell and internal soft animal, which fills it. The shell is concamerated, or, to speak more correctly, is composed of several cells, arranged in a series either discoid or spiral, or aggregated; the cells communicating by large openings, all filled by connected tubes of the animal substance, and (usually) perforated on the free surfaces by many small holes, which give passage to fine ciliæ, or pseudopodia, like the ciliæ of bryozoa.

The ovary, digestive canal, &c., are known to take a direction through several cells; no nervous system has yet been seen; no vascular circulation is known; no special organs for respiration; and in general, though the shell is polythalamous, the animal is not a Cephalopod,

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but Acephalous, and of the Zoophytic type. The shell is *calcareous.*

Animals of this kind seem to have had little or no locomotion, beyond what belongs to the ova of many invertebrata. The ciliæ probably produced currents in the water, as the ciliæ of the Sertularidæ do.

The recent Nonionina and Rotalia have been fully described by Ehrenberg *(Taylor's Scientific Memoirs.)* The specimens which he examined were from Cuxhaven.

Rotalia is a spiral and discoid form, composed of six or more nearly globular cells, the last being largest.

Textilaria is spiral or plaited round an axis, and resembles often a small spiral Gasteropod.

Nearly all the Infusorial fossils belong to the peculiar group of forms which the Botanist claims as jointed algæ, or disjointed algæ; and the Zoologist regards as self-moving self-dividing animals, having (in some) digestive cavities within the body, and (in some) external vibratile ciliæ. They are found associated (jointed algæ), or detached (disjointed algæ). They are all externally covered by a *siliceous shield* or shell, by the forms and structures of which the genera and species are determined.

It appears from the researches of Ehrenberg, that the species found at Bridlington are nearly all now living at this present day. It is somewhat difficult to assure ourselves of this perfect identity, in respect of such microcosms; but observers agree in the statement that no clear or certain mark of distinction appears between the fossil and recent specimens of the Navicula, which have been named as under:—

Navicula phœnicenteron.
„ inæqualis.
„ viridis.
„ gibba.
„ scalprum.
Bacillaria vulgaris.

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This conclusion of the identity with living types of many of the Infusorial forms, which occur in tertiary and supra-tertiary deposits, is in harmony with researches into other tribes of fossil animals. But, in extending our view to older strata, some difference arises in this respect. It is well known that at the most, only one or two species of the fossil shells which occur in the chalk are identical with recent shells; and there is no other tribe of the animal kingdom, except the microscopic races, which yield even one such analogue, in the chalk or strata below. But of the microscopic Infusoria, Ehrenberg mentions three living species which occur in the flint, viz.:—

Peridinium pyrophorum.
Xanthidium ramosum.
„ hirsutum.

And three others, which occur in the white chalk, viz.:—

Fragilaria rhabdosōma.
„ striolata.
Gaillonella aurichalcea.

He also enumerates in the white chalk of England, Denmark, and Sicily, nine species of Foraminifera, which are also living in the sea, viz.:—

1. Globigerina bulloides.
2. „ helicina.
3. Rosalina globularis.
4. Rotalia ocellata.
5. „ globulosa.
6. „ perforata.
7. „ turgida.
8. Textilaria aciculata.
9. „ globulosa.

If we reflect on the *number* of the fossil forms here referred to living types, the great skill and patience of the observer, and the support which he has received to a certain extent from other naturalists, we shall be disposed

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to accept the conclusion of M. Ehrenberg as probable. It is, moreover, confirmed by the facts already alluded to, of one or two species of recent shells, (Terebratula caput serpentis and T. vitrea,) which are regarded by eminent naturalists as undistinguishable from the T. striatula and T. subundata of the chalk.

We must, therefore, admit, in respect of the living species of these microscopic Foraminifera and Infusoria, an earlier date among the stratified rocks than belongs to nearly every other living type; an interesting conclusion, on which M. Ehrenberg has founded a series of propositions, which are valuable, but less novel than some authors suppose. For it is not only perfectly well established in Geology, that each group of life has its own laws of distribution in the earth, which can only be known by observation, but further, that the Geological range through which fossil species occur is greater in the invertebral than in the vertebral tribes; greater in the Mollusca than in the Crustacea; and greater in the Zoophyta, to which these fossil Foraminifera, and some at least of the Infusoria, belong, than in any other grade of animal life.

In accordance with this view, we find in the Mountain Limestone, Zoophyta and Mollusca, which are referrible to existing genera, with Fishes of extinct genera, but no Reptiles; in the chalk, Reptiles of extinct genera, with Zoophyta and Shells, of which one or two belong even to living species; and in the marls of Bielbeck, in Yorkshire, thirteen forms of Shells, belonging to species now living, with the extinct Elephant, Rhinoceros, and Lion.

The subject to which I have called your attention to-day is one which it is difficult to guard from the rash hands of cosmogonists, who see in every new Geological discovery only an advanced post of science, which they, if auxiliaries, would unwisely push beyond the point of security; if enemies, would as unwisely attack with their whole dis-

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ordered force. But Geologists, who comprehend the true basis of their science, and desire to see it make real progress, will follow the process which has been found successful in every other branch of the knowledge of nature. They will not draw general conclusions from solitary facts; they will not build a system of extinct and living nature on microscopic Infusoria, but combining what is now discovered with what has been established before, will enlarge their data, correct their reasoning, and thus continually advance toward what is so important in science, and valuable in practice,—a true natural history of the stratified crust of the globe.

The Rev. Dr. Scoresby, of Bradford, expressed his gratification at the paper they had just heard. In the course of his own experience in the Northern Seas, he once perceived some large portions of the water of a deepish yellow colour. He took a small quantity and bottled it, supposing that it might be some living creatures that caused that colour. To his delight, he found, on placing it under a microscope, that there were no less than 26,000 living creatures in a single drop of that water; they having, evidently, abundant space for enjoyment, and perhaps one of their highest pleasures was in being confined in such a short space.

William West, Esq., F.R.S., of Leeds, then read a paper "Upon some Peculiar States of Water at High Temperature, and upon the Freezing of Water in Red Hot Vessels." These, he said, were first made known to chemists by M. Boutigny, at Cambridge. Some of M. Boutigny's views had been called in question, and it was disputed whether the explosion of steam boilers ever arose from the cause described. He was not going to enter into a discussion on the subject, but to show a few experiments rather in explanation than in defence of Mons. Boutigny's views on the subject. These experiments had

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been compared to a practice used in the laundry, of spitting upon a hot smoothing-iron to ascertain whether it was sufficiently hot. Mr. West having brought to a red heat a small platina dish, let fall upon it a few drops of water, which did not pass off as steam, but continued to roll about the vessel like large globules of quicksilver, although heated much beyond the boiling point of water. Immediately, however, on allowing the platina cup to cool a little, the whole of the water passed off in a state of steam. Mr. West proposed to call these the adherent and the non-adherent states, in place of the terms spheroidal, used by M. Boutigny. Another experiment was in a boiler, with a cork placed in it, instead of a safety valve. The boiler was first made red hot, and water was poured into it, which remained without apparent change; but immediately on taking the boiler from the fire, and allowing it to cool, the whole of the water was converted into steam, driving out the cork with a violent explosion, and causing an escape of the whole of the steam contained in it. The third experiment was the conversion of water into ice in a red hot vessel. Liquid sulphurious acid, and water, were poured at the same time into the red hot capsule; the water, prevented from contact with the vessel by the great heat, was cooled by the evaporation of the acid, and immediately converted into ice. These experiments by Mr. West excited a high degree of interest, and were performed with great skill and adroitness.

The Rev. Dr. Scoresby rose to mention a circumstance in illustration of the paper and experiments of Mr. West. It was an eruption of Mount Etna, from which an immense quantity of liquid lava flowed down towards a lake, in the presence of a number of spectators. When the lava came very near the lake, the people all fled, expecting an explosion; but, to the surprise of all, it went in quietly, and produced

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no effect whatever. The people then returned to see the wonderful sight; but, as soon as the lava had got sufficiently cooled down, an explosion did take place, and such a mass of hot water was thrown out, that sixty persons lost their lives on the occasion.

The Doctor then proceeded to give extemporaneously his paper, "Observations on the Currents and Phosphorescence of the Atlantic." He gave at considerable length the result of his observations when sailing at various times across the Atlantic, and in the Northern Seas. He said it was not true that the under-currents were stationary; for the water might be moving at the surface in one direction, and the lower part in another, as the same rule governed the currents of the ocean as of the air. Hence they saw the clouds going one way while the wind was blowing another. On the subject of the phosphorescence of the waters, there was a difference of opinion as to the cause; but he had no doubt that the main cause was the existence of small animal bodies, many of which had the property of being luminous when agitated and disturbed in the dark. On one occasion, when going across the Atlantic, he had observed that when the water was a rich blue colour, there were very few living things in the water; and the ultramarine colour was the purest water. But when the sea became a sort of bottle-green colour—he procured some, and found there were in it a quantity of animalcula, among which were some very remarkable creatures, and also a vast number of molluscous animals of a spheroidal form, which attached themselves to each other in rays of regular order; subjecting themselves to one motion, so that if one only moved, the others must also move in the same way.* On some occasions, when these animals were in action at the surface of the waters, the sea presented the most beautiful appearance—that

* Probably of the genus Salpa?

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of a liquid fire; the waves being crusted with luminousness, and the appearance altogether grand and imposing.

THE EVENING MEETING.

Earl FITZWILLIAM having resumed the Chair,

The Rev. Dr. SCORESBY described at some length one or two interesting communications which he had made at the recent meeting of the British Association at Cambridge, embracing that by Mr. Hunt "On the Changes produced by the Solar Rays;" and another by Mons. Couloier Gravier, "Observations on Falling or Shooting Stars at Rheims and Paris," who had ascertained that in the Northern quarter there were, on an average, 74 per day; in the Eastern quarter, 114; in the Southern quarter, 63; and in the Western quarter, 33. He found that the time for the greatest number was six in the morning, and the fewest at six in the evening. The greatest number was on the 9th of November, and the next greatest number was on the 8th and 9th of August. The number of 5,202 shooting stars had been perceived in 1,054 hours, an average of five in an hour. The result of his calculation was, that about six millions of these shooting stars were occurring annually within sight of the observer. The Doctor lastly described a large magnetic machine of his own construction, with some results of its action.

Mr. DENNY then read the following paper:—

ON THE FOSSIL ANIMAL EXUVIÆ OF THE YORKSHIRE COAL FIELD. BY HENRY DENNY, A.L.S., ETC., OF LEEDS.

As every attempt, however slight, to illustrate or investigate the Geology or Zoology of any particular district cannot fail to be of some service to science, I venture to submit to the

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Geological and Polytechnic Society of the West-Riding, a brief sketch of the *Fossil Animal Exuviæ of the Yorkshire Coal Field.* That the list which will be submitted to you is imperfect I feel fully persuaded, from my not having had the opportunity of ascertaining what the different collections in the neighbourhood contain. But it occurred to me, that if some individual prepared the skeleton of a catalogue, it might be amplified and rendered more complete by those whose information was more extensive, and thus form a synopsis worthy of the attention of a Society whose particular province it is to collect, collate, and register facts especially connected with the local Geology and History of the West Riding of Yorkshire, that being the kind of information which practical Geologists will naturally expect them as a body to supply; for it is by recording observations though in themselves apparently unimportant, that materials are furnished for more extended and valuable investigations.

The Coal Field, whose relics we have to consider, extends in length, as is pretty generally known, from Moor Allerton, North of Leeds, to Sheffield, and is there further extended into the adjoining counties of Derbyshire and Nottinghamshire; its greatest breadth, I believe, is between Halifax and Pontefract, about 20 miles. Throughout this extent of country, there are several distinct Coal seams or beds, which are designated by the name of the locality in which they are principally worked. Thus, the lowest is that worked at Halifax and neighbourhood, at the depth of above 200 yards, which extends to Idle, Rawden, Kirkstall, and Moor Allerton, where it crops out at only a few inches in thickness, and is of no use as Coal, or worth working. This seam, above all the others, is peculiarly characterised by some organic remains, which we shall have shortly to allude to. The next in importance above it is the Low

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Moor coal, or that worked at Low Moor, Bowling, and Bradford; above this bed is another worked also at Low Moor and Royds, called the black bed. The next in order is the Beeston Coal; next follows the very valuable Coal seams worked at Middleton, Rothwell Haigh, Waterloo, and Wakefield Outwood Collieries, which are succeeded by those of Lofthouse, &c. With the identity or not of some of these seams, I have nothing to do; I only allude to the most generally recognized Coal beds, as the source from whence fossils have been received.

This part of the Carboniferous system is distinguished from all the other formations by the much greater abundance and elegance of its fossil plants, which is only what we should, *à priori*, expect, knowing as we do that this valuable deposit owes its existence to vast accumulations of vegetable matter. The plants, therefore, have been long known and acknowledged, though not until very lately accurately identified and classed. But the remains of the higher divisions of the animal kingdom were not even supposed to occur at all. Mr. Conybeare, indeed, in his valuable "*Geology of England and Wales*," says, "The remains derived from the animal kingdom are very rare, and entirely confined to a few species of Testacea, excepting that in *one* instance a fragment supposed to have been part of the radius of a Ballistes has been found." That this opinion was unfounded, I need scarcely say, when our own district furnishes such abundant evidence to the contrary. Nay, I believe I may assert, without fear of contradiction, that the West Riding produced the *first* well authenticated specimens of Ichthyological Exuviæ, from the Coal formation, in the justly celebrated Heads of Megalichthys, from the Low Moor and Waterloo Collieries, drawings of which were sent to Cuvier, in 1823, for his opinion as to their Reptilian or Fish nature.

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That the enumeration of Animal Exuviæ, which will be submitted to you, is meagre, I cannot deny; but from what has just been stated, I presume every one will be prepared to expect this:—that is, as compared with the earlier and subsequent formations. This is more especially the case, however, with the Invertebrate tribes. No Zoophytes, no Crustacea, (with a solitary exception), no Echinodermata, and only a few Molluscous Animals and Conchifera. This paucity, however, is easily accounted for, if we consider Coal as a fresh-water deposit in the first instance, in which we must all be well aware the number of Molluscous Animals and Crustaceans, whether in rivers, lakes, or ponds, is very small, when compared with the countless myriads and variety of forms which people the ocean; and add to which, the total exclusion of Zoophytes, Echinoderms, Acalephæ, and Tunicata, &c. Reasoning, then, upon such premises, only a very limited proportion of the former inhabitants of such localities can be expected to occur in the Coal strata. For instance, of the Brachiopodous Conchifera, six hundred fossil species are known in the older rocks. In the Coal strata, we have only one or two at most. How is this to be accounted for? They are *all marine*.

As we find the quality of Coal varies in different parts of the kingdom, so also do we find varieties in the fossil remains, which is a point of great interest. I am not aware that examples of the fossil Flora have ever been found associated with the exuviæ of Vertebrate animals; with Invertebrate, they are occasionally.

These facts, if duly investigated, may probably throw some important light upon the different circumstances under which the various Coal seams were deposited. Were any Vegetable relics ever found in the cannel or stone Coal? I believe not. While, on the other hand, the remains of our largest fishes are *there* the most abundant. The

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Ichthyolites are generally in a highly bituminous shale, sometimes forming the roof, and at other times the floor, of the Coal seam; while the fossil plants occur in the argillaceous shales and sandstones, which occupy the same situation, but appear destitute of the former substance. Can the presence of bituminous matter in the one instance, and its absence in the other, be owing in any degree to the decomposition of animal substances? which has been conjectured by some writers as affording a probable explanation of the difference which they present in mineralogical analysis.

The different seams of Coal, even in the same pit, will not always yield the same remains. At Middleton, there are three seams, known as the Fish Coal, Yard Coal, and Main Coal. In the roofing shale of each of these seams fish remains occur, but in the first more especially; hence the colliers have designated it the Fish Coal, and Mr. Teale the Ichthyophorous shale. In the Main Coal shale, we find a much smaller number of fish exuviæ, but they are of a peculiar character and of greater magnitude, such as large vertebræ and dorsal rays or spines, &c., of shark-like fishes; while the Yard Coal is still more deficient, and contains only a few small teeth of Holoptychius and Ctenoptychius.

"The manner," observes Mr. Williamson, "in which Ichthyolites are associated with other remains in different localities is well worthy of attention. At Burdiehouse, they occur in the midst of Unios, Cyprides, and Microconchus Carbonarius; at Colebrook Dale, with species of Orbicula, Trochus, Nautilus, Orthoceras, and Conularia; in the Lower Measures of Lancashire, in beds nearly associated with those, containing Goniatites Listeri, and Pecten Papyraceus; in the Higher Measures of Lancashire and in Yorkshire, with Unionidæ and Entomostraca;

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at Middleton, with Lingulæ; at the top of the series in Lancashire and Derbyshire, with Mytili."

The highest class of vertebrate animals whose remains are found in the Coal Measures, is that of Fishes. On the continent between Coblentz and Cologne, there is what is termed the brown Coal formation or paper Coal, (a more recent deposit, however, than the Coal Field,) in which are found besides Fishes, Batrachian Reptiles, as the frog, &c. Mr. Lyell states that an entire jaw and other bones of an extinct mammiferous quadruped, the Anthracotherium, have been found in the Coal beds of Cadibone, the bone itself being changed into a kind of Coal. In these beds, however, although comprising Carbonaceous shales, and several seams of Coal from two to six feet in thickness, no shells have been discovered, nor impressions of plants of which the species can be determined. In the Yorkshire Coal Field, though we cannot lay claim to any quadrupedal or reptilian remains, still we have the fishes of various genera and species, which are of great importance to the Geologist. "Fishes," observes Agassiz, "being more than all other animals most intimately connected with the incidents of the water, and their organization being besides very high up, they are better calculated than any other class to give us clear ideas regarding the changes which have been going on in such vast seas as have formerly covered over the earth. We shall be enabled to determine if a fish has lived in rivers, in lakes, or in ponds; in the high sea or upon its shores; if it was an inhabitant of the surface of the water, or of its great depths; which indications, more or less valuable, will aid us in determining corresponding circumstances with regard to the formation of rocks." To enable the Geologist, however, to bring so successfully Zoological identity to his assistance, he must enter into the labours of the Comparative Anatomist, and Zoologist, and study the minute structure and characters

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of animals, which the world at large think of little value; inasmuch as he will frequently have only a small portion, nay, perhaps, only a scale of a fish, to work out his problem by, yet it is by such an accurate knowledge of small things, that results of the greatest interest may be come at. Who would have believed, a few years ago, that we should be able to declare with precision, the exact species of fish which formed perhaps the principal food of the Ichthyosaurus, from the undigested scales which are seen in the Coprolites from Lyme Regis, or that have been sealed up for ages, in the stony stomach of these monsters of a primeval world. Yet this has been done, and from a single scale. (Vide "*Dr. Buckland's Bridgewater Treatise*," p. 191, to which work I am indebted for much valuable information occurring in this paper.) It is thus by attentively examining the peculiar diagnostic characters which the scales of each family, genus, or species of fish presents, that Agassiz has been enabled to apply his classification of fishes, with so much effect, to Geological investigations, it being based upon the dermal covering which appears the most durable. This partly arises from the fact, that the enamelled condition of the scales of most fishes, which existed during the earliest Geological epochs, rendered them much less destructible than their internal skeleton; and cases frequently occur, where the entire scales or figure of the fish are perfectly preserved, whilst the bones within these scales have disappeared altogether. Hence the perfect character of the different families of fishes will be preserved for ages, though not a vestige of their muscular or bony supports remain. Thus are their very portraits indelibly stamped on their rocky sepulchres. And it is of importance from these medals of creation to notice, as Dr. Buckland observes, "That all the great changes in the characters of fossil fishes, have taken place simultaneously with the

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most important alterations in the other classes of fossil animals and vegetables, and also in the mineral condition of the strata. Hence we find that the genera of fishes which prevail in strata of the Carboniferous order, are found no more after the deposition of the Magnesian Limestone. Those of the Oolitic series were introduced after the Magnesian Limestone, and ceased suddenly at the commencement of the Cretaceous formations. The genera of the Cretaceous formations are the first that approximate to existing genera. Those of the lower Tertiary deposits of London, Paris, and Monte Bolca, are still more nearly allied to existing forms; and the fishes of Oeningen and Aix approximate again yet closer to living genera, although every one of their species appears to be extinct. Not a single species of fossil fish has yet been found that is common to any two great Geological formations, or living in our present seas. In 1836, M. Agassiz had determined upwards of 1,000 species of fossil fish, of which about 400 were British, whose Geological distribution approach somewhat to the following,—Silurian system, 5 or 6; Old Red Sandstone, 20; Coal Measures, 56; Magnesian Limestone, 16; Oolitie series, 150; Green Sand and Chalk, 50; London Clay, 50; Crag, 5 or 6; since which period the numbers are greatly increased, especially in the Old Red Sandstone.

Having dwelt longer than perhaps I am justified, in introducing to your notice the value of fossil fishes, in a Geological point of view, with their distribution, I must now proceed to my analysis of the animal remains in our own Coal Field. For the information of those who may not have looked into the subject, I feel it necessary to explain that the four orders under which the fish are classed, is in accordance with the views of M. Agassiz. 1. The *Placoidians*. 2. *Ganoidians*. 3. *Ctenoidians*. 4. *Cycloidians*. Each of these orders existed during particular Epochs. Only

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the Placoids and Ganoids existed before the commencement of the Cretaceous formations. The Ctenoids and Cycloids, which contain 600 out of the 8000 known living species of fishes, appear for the first time in the Cretaceous strata, when all the preceding fossil genera of the two first orders had become extinct, which are those only to which we shall have to refer. Of the Placoidians, the most frequent remains observed in the Coal formation belong to the Shark family. The specimens which have come under my notice, consist of the teeth and dorsal Spines, or Ichthyodorulites, as they have been called, of the Hybodonts; of these, fine specimens of Gyracanthus formosus, and Pluracanthus planus, have been found at Middleton and Adwalton; Ctenacanthus brevis, and Orthacanthus cylindricus, in the stone Coal at Adwalton; of the Cestracionts, only palatal teeth have occurred, and these sparingly; of a species of Helodus and Ctenoptychius pectinatus, at Middleton; also a fine, and I believe unique, specimen of Ctenodus cristatus, upon a piece of Coal from Tong, preserved in the Museum of the Leeds Philosophical Society; teeth of Diplodus gibbosus and Hybodus obtusus, at Middleton. M. Agassiz also enumerates, Petalodus acuminatus, from Leeds, and Carcharopsis prototypus, from Yorkshire, which I cannot trace. As these animals are amongst the most universally-diffused and most voracious of the modern fishes, so there is no period with which Geology is familiar, in which either true Sharks or analogues equivalent to them, did not exist. Agassiz determined the existence of more than 150 extinct species of fossil fishes allied to this family. The first and oldest, the Cestracionts, beginning with the Transition strata, appears in every subsequent formation, till the commencement of the Tertiary, and has only one living representative, the Cestracion Phillipi of Port Jackson. The Hybodonts, beginning with the Muschel Kalk, and probably Coal formation, prevails throughout the Oolitic series, and ceases

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with the commencement of the Chalk. The Squaloids or true Sharks commence with the Cretaceous formation, and extend through the Tertiary strata up to the present time. In these successions, we see, in the clearest manner, the wisdom and the true knowledge of the Creator, who in the beginning laid down, as it were, certain fixed laws for the government and well-being of his creatures, and pre-ordained that certain offices or processes should be constantly in progress, to prevent the too rapid increase of particular tribes of beings, or for the purpose of cleansing the waters of accumulated vegetable substances, which it was necessary to remove, to prevent their proving injurious. But though these various offices were constantly going on at different epochs, it has been by the aid of different agents, each making way for its successor, perhaps better adapted by organization for the especial purpose than the preceding.

Of the Ganoidians, the first which claims our attention is the Sauroid Family, consisting of those insatiable lizard-like fishes, which possess highly important characters, combining those of the reptile and the fish. Seventeen genera of Saurian Fishes have been discovered fossil, while they have only two living representatives,—the genera Lepidosteus, inhabiting the fresh-waters of America; and the Polypteris, the Nile and rivers of Senegal. The largest fishes yet discovered of the Ganoid order belong to the genus Megalichthys, which appear to have been extensively distributed through the Coal Fields of Great Britain, more especially in the cannel or stone Coal;—the first examples, and also the most celebrated and unique, being the nearly perfect head and portion of the body of Megalichthys Hibberti, from Low Moor, deposited in the Museum of the Leeds Philosophical Society in 1823. Subsequently a smaller head was found at the Waterloo Colliery, which is also in the same Museum; since which period numerous scales and teeth have been detected at Middleton

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and Adwalton. From the latter locality, especially, several very fine teeth, upwards of two inches in length, have been obtained by Mr. Drabble, of Leeds, who was informed by one of the pitmen that a large mass of scales, &c., in length equal to one of the corves, had been brought up and broken to fragments at the pit's mouth. Several small jaws occur in the fish coal at Middleton, but whether belonging to the young of the same species or of a second I cannot determine, though M. Agassiz enumerates two species from Leeds, viz., Megalichthys Hibberti and maxillaris, the latter of which he does not describe or figure. Numbers of small Sauroid teeth have been obtained in the stone Coal at Stanley, Newton, and Overton, near Wakefield, associated with a large proportion of Coprolites; also at Rothwell Haigh; and in the roof of the better bed of Coal at Low Moor, but more sparingly.

The fins, scales, and operculi of a species of Acanthodes, as also the scales of two or three species of Holoptychius, are not uncommon in the Middleton fish coal. The latter, I presume, belonging to Holoptychius sauroides, and minor, which Agassiz enumerates as from Leeds. He also mentions Platysomus parvulus and Diplopteris carbonarius. In whose possession these are, or from what part of the neighbourhood, I cannot ascertain. The last fish I shall have to mention is Cœlacanthus Phillipsi, of which a portion, appearing to be the tail, was found in the centre of a baum pot, near Halifax, and now belongs to the Museum of the Philosophical Society of that town. A second species, C. lepturus, is recorded by Agassiz from this neighbourhood, but of which I know nothing.

Proceeding from the only vertebrate animals found in the Carboniferous system, we are led, owing to a remarkable peculiarity in the Yorkshire Coal Field, (I mean the occurrence of a purely marine deposit, or at least a seam of Coal characterized by containing only marine animals, known as

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the Halifax Coal,) to the very next group of animals succeeding the Vertebrata; the highest of the invertebrate division being the Cephalopodous Mollusca. In the Halifax Coal we find the Goniatites Listeri throughout its entire course, though not in equal perfection; for while in some districts the shell is perfect, and, owing to the presence of iron pyrites, has a beautiful metallic lustre, at other places, as for instance at Moor Allerton, where the coal is reduced to a thin bed of black-looking earth, the shells are compressed and nearly flat. Capt. Thomas Brown enumerates, in the Transactions of the Manchester Geological Society, G. mutabiles and G. calyx, from the Coal shale near Todmorden. In the Catherine Slack Coal beds, near Halifax, a species of Nautilus has been discovered, which is described and figured in the Proceedings of this Society, page 182, by Dr. Inglis, under the name of Nautilus Rawsoni. In the Museum of the Leeds Philosophical and Literary Society I have since detected a specimen of this shell, which has been there many years. In the Museum of the West-Riding Geological and Polytechnic Society is also a portion of another specimen, found in excavating the tunnel for the Sheffield and Manchester Railway, at Dunford Bridge. Another genus of this group, Orthoceras, occurs in the same bed, but is not very extensively distributed. This is represented by the Orthoceras Steinhaueri found in the Halifax Coal at Holmfirth; and remarkable as it certainly is, without any break in the classification, we next arrive at the order which immediately succeeds the Cephalopoda, the Trachelipodan Mollusca, which are represented by the Melania Greenwoodi, from the roof of the Dulesgate Coal at Todmorden. Here, then, we arrive at the first disruption in our classification, as I have no knowledge of any examples of Gasteropodous Mollusca being found in this district. But very singular again, the next shells which claim our notice are of marine origin, and belong to the Acephalous Mollusca.

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The first genus of the Brachiopodous Conchifera is Lingula, which is represented by the Lingula ægis, from the roof of the Middleton Coal; but whether it extends to any other seam I have not heard, though, from its marine nature, we might expect it to occur in the Halifax Coal. The last marine shell I have to enumerate is the Pecten Papyraceus, which I need scarcely say is the principal diagnostic fossil of the Halifax Coal, and is found at its extreme limit in Derbyshire. It occurs in great numbers, compressed into thin layers, which rapidly decompose, from the quantity of iron pyrites associated with them.*

We now arrive at the extensive fresh-water deposit which passes throughout the entire Yorkshire Coal Field, into Nottinghamshire and Derbyshire. It is scarcely necessary to say I allude to the seam or seams of iron-stone, filled with such multitudes of fresh-water shells of the family Unionidæ, known as the mussel band. These shells were long supposed to be of only two species, the Unio subconstrictus and acutus. Capt. Brown, however, who has been investigating these shells, has published a list of twelve more species from the neighbourhood, under the genus Pachyodon, which are as follow:— Pachyodon bipennis, Dawsoni, amygdala, exoletus, antiquus, and pyramidatus, from Low Moor; Pachyodon nanus, similis Blaydsii, transversus, and levedensis, from Middleton; and Pachyodon turgidus, from Wakefield. The appearance which these shells present is worthy of notice, not only from the high state of preservation in which they occur, (retaining in many cases their original colour,) but from the circumstance of their accumulation of all ages and sizes, living and dead; some having been evidently dead before submersion, from the fact of the valves being so widely extended, which is

* In Lancashire, the Goniates and Pectens do not characterize a single bed, but extend over *five* distinct beds.—*Transactions of the Manchester Geological Society, p.* 88.

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never the case during life, and could not have arisen from the weight of the superincumbent deposit, the effect of which is seen on numbers of specimens entirely crushed in every position; therefore is solely owing to the decomposition of the muscular attachments and ligaments. I am aware that various opinions exist as to the fresh-water origin of the mussel band, as proved by the shells, which might possibly have been marine. That they are not marine I conceive is fully proved by the occurrence in the same band of such vast multitudes, almost strata, I was going to say, in some instances of a small species of Entomostraca, which is the only example of the class Crustacea in our Coal Field, and the last animal to which I shall call your attention on this occasion. The creature alluded to is Cypris arcuata. Now, that the genus Cypris is fluviatile or lacustrine is universally admitted; I cannot see, therefore, how we can account for the myriads of these animals in connexion with the Unionidæ, unless they were both tenants of the same fresh-water lake. The habits of these little creatures are well known. They are to be seen in numbers in stagnant waters, marshy pools, ditches, &c., moving about with great rapidity. The Cypris is covered with an oblong sort of shell, of two valves, somewhat kidney-shaped, which is the only durable portion of its body, and which, like many other species of Crustaceans, is shed annually, and will then fall to the bottom of the water, and form a stratum with the Unios; thus showing us that the former were not suddenly brought to the spot, but inhabited the particular locality for a long period, and left their annual exuviæ to attest most clearly the tranquillity of the waters in which they were passing through successive generations. Hence our analysis of animal remains in the Yorkshire Coal Field stands thus—Fish, 17 species; Cephalopods, 5; Mollusca and Conchifera, 17; Crustacea, 1;—total 40.

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Here I am compelled to close my list for want of other examples, which I have little doubt exist, if persons could only be induced to preserve every specimen they meet with in the Coal formation. This can only be done, however, by a slight remuneration being held out to the colliers. Dr. Hibbert proved this when collecting the Burdiehouse fossils. The men, one and all, declared that in the long course of their quarrying operations no remains whatever, save those of plants, had ever been the object of their visual organs. But having convinced them that bones did exist, and stimulated them by the promise of a reward for what they should find, the Doctor was presented with an excellent physiological example of the capability which such a stimulus had of increasing, to an almost miraculous degree, the vividness of optical perceptions. The men, to use their own words, now "saw with new eyes;" large scales, large bones, along with the remains of small fishes, became palpable, and, as if by the force of a magician's spell, were revealed in a profusion most admirable to behold.

The CHAIRMAN announced that the next meeting would be held at Doncaster, and proposed a vote of thanks to the Mayor and Corporation of Pontefract, for the accommodation they had afforded the Society.

The MAYOR acknowledged the compliment, and proposed a vote of thanks to the Chairman, for his kindness in taking the chair, and for honouring them with his presence.

On the motion of R. M. MILNES, Esq., M.P., a vote of thanks was also given to the gentlemen who had contributed papers on the occasion.

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE THIRTIETH QUARTERLY MEETING, HELD IN THE MANSION HOUSE, DONCASTER, ON FRIDAY, OCTOBER 24TH, 1845.

The Right Hon. the Earl FITZWILLIAM, F.R.S., President, having taken the Chair,

A paper was read, of which the following is a summary:—

ON THE APPLICATION OF ELECTRICITY TO THE ARTS. BY MARTYN J. ROBERTS, ESQ., F.R.S.E., F.R.G.S., ETC.

He commenced by first showing that galvanism is but another name for electricity generated by chemical action, in distinction from electricity generated by friction, usually called frictional electricity. He then demonstrated by experiment, that two metals (one more easily oxidated than the other), if plunged into dilute acid, decomposed the water, and generated a current of electricity; these two metals thus in action formed a galvanic pair, and if the circuit be completed either by a wire junction of the metals or other conductor of electricity, a current of electricity circulates through the conductor. If this circuit be not homogenous, the points of contact of the various conductors are called poles; those where the electricity enters is called the negative, those from which it issues, the positive pole. Mr. Roberts then laid down the axiom, that when solutions are decomposed by electricity, that oxygen and the acids go to the positive pole, while hydrogen, metals, and bases of salts, go to the negative pole: this axiom he stated to be the

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principle on which many of the practical applications of electricity were based. He then explained the process of assaying copper and other ores by electricity, a process he himself invented some years ago, and which is now in very general use, and is so simple that the most unlearned can avail themselves of it. The following is the process:—Suppose we wish to assay a copper ore, dissolve 400 grains in acid, in the usual manner, dilute with water, and put into a glass or earthen jar; then take a strip of copper plate, about one inch wide and two inches long, having a wire six inches long soldered to it; procure also an iron plate of a similar size, having a wire soldered to it; cover the iron plate with brown paper, and weigh the copper plate with great exactness; then twist the wires together, and plunge the two plates into the dilute solution of the ore; allow them to remain there until all action ceases; then free the copper plate from the iron, dry it, and re-weigh it, and the excess over the former weight will be the exact amount of copper contained in the 400 grains of ore, because the axiom mentioned has come into play; the solution of metal is decomposed by the electric current generated by the two plates or galvanic pair; the oxygen and acid have gone to the iron plate (the positive pole), while the metal copper has gone to the copper plate (the negative pole), and on this plate it will be seen in a bright metallic state.

A variation of this process, but based on the same law, is the electrotype and electro-plating process; the object to be covered forms the negative pole of a galvanic battery or pair; and this object being plunged into a metallic solution,—copper, silver, or gold,—is in a short time covered by the metal. The whole of these processes were shown by Mr. Roberts. He then explained the principle of preserving metals by electric action; for example—Sir H. Davy's attempt to preserve the sheathing of ships. He next touched upon the mechanical preservation, such as what

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is called galvanized iron. He entered fully into all these subjects, but our space will not allow us to give a full detail of these interesting matters; indeed, it is not so essential we should do so, as, we believe, Mr. Roberts intends publishing a detailed but popular explanation of the several applications of Electricity to the Arts. He next showed the action of an electric current running parallel to a magnetic needle, by which the needle tends to place itself at right angles to this current; this portion of the subject was illustrated by numerous interesting experiments, the more interesting as they explained the principle of Cooke and Wheatstone's Electric Telegraph, the action of which Mr. R. afterwards described. He then explained the electric clock, the formation of magnets of soft iron by electricity, motion of machinery by electricity, all illustrated by many conclusive experiments.

At the conclusion of Mr. Roberts's paper, the Noble Chairman called upon Professor Phillips to give his paper, of which the following is an abstract:—

OBSERVATIONS ON THE PROCESS OF PETRIFACTION. BY JOHN PHILLIPS, ESQ., F.R.S., F.G.S., ETC.

The observations which he should have the honour to address to the meeting related to a class of phenomena amongst the most frequent in Geology,—amongst the most interesting in that important science, and upon which a great variety of important facts were collected. He had to speak to them on the subject of the petrifaction of fossil and organic remains. He believed that there was no person who had inquired into the science of Geology but would be ready to acknowledge that one reason for the slowness with which Geological truth made way, was the inherent difficulty connected with its explanation. Things clear as the light, when they saw them in nature, were often rendered extremely difficult when they came to

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be explained in a lecture. And this was not from any fault of the teacher; but from the manner in which he must pursue it, it is impossible to give correct general terms applicable to the knowledge of the subject. Words which were generally well understood were used in a technical sense by geologists; and among these he would instance that even the word "rock," the meaning of which every one was familiar with, was by geologists used in a technical sense.

Having thus premised the observations he had to make, Professor Phillips went on to observe, that plants and animals were imbedded in the earth, and underwent in the course of ages a variety of changes, either mechanical or chemical. All analogous strata were of equal antiquity; and some recent formations contained transformations as perfect as those which were formed from the ancient deposits. He was prepared to believe that all classes of coal were derived from plants; and he would call the attention of the meeting to some facts in proof of his assertion on that subject. One of these, That he had cut and polished a great number of pieces of jet, which he had found on the Yorkshire coast; and he had found in all of them the texture of the wood as clear and as distinct as if it had been cut fresh from the tree. In addition to this, he alluded to some illustrations of the subject which had come under his observation, in respect of a cutting which had been recently made by the Aire and Calder Company, in the neighbourhood of Ferrybridge, where they had discovered what was, in fact, a subterranean forest. The soil was alluvial, and in one part of the cutting it went over this subterranean forest, which was composed of hazel bushes, containing fine clusters of nuts, which were imbedded at a depth of about fourteen feet. Some of the wood was unchanged, but in some instances both the wood and nuts were changed. There was no

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instance in the whole collection where the bark of the wood was converted to stone; but the internal part was found to be in that state. On examining these nuts, he found that the external shells were entirely unaltered, but the kernels of the nuts were converted into stone; and the brown membrane over the kernel was unaltered, as well as the shell. This certainly appeared very remarkable; but it was evidence to show that a certain law obtained in regard to these changes. He had a portion of the fossil wood so converted into stone now in the microscope, and it presented as beautiful and as perfect a specimen of hazel wood as could be seen. With respect to the nuts, he believed that the change was owing to their having been permeated by water that had passed over a bed of limestone.

Coral and calcareous shells had, in some instances, been dissolved by a solution passing through the rock containing them. These left a cavity, which, being filled up by another solution subsequently passed through, took the shape of the original shell, the substance being entirely changed. It was well known that a portion of the pillars of the bridge of Trajan, crossing the Danube, had become converted into flint by means of chemical action.

The Professor next proceeded to describe an ancient boat and some other matters which had been found imbedded in the banks of the Calder, near Stanley Ferry; and also the lower jaw of a Red Deer, found a few years ago imbedded in Hatfield Chace, and sent to the Museum at York. The jaw, bones, and teeth were altogether quite flexible. They had lost the whole of their hardening earth, and retained the gelatine; which gelatine had become tanned by the peat, and thus the whole were actually converted into leather. In proof of this most remarkable phenomenon, the Professor held up to view the jaw in question, which was as pliant and flexible as a piece of prepared leather.

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At the conclusion of this very able paper, Professor Phillips informed the meeting that the specimen of petrified hazel was in the microscope on the table, for the inspection of the company.

Mr. E. CHARLESWORTH, F.G.S., Curator of the Yorkshire Philosophical Society, was next introduced to the meeting by the Noble Chairman, and proceeded to give his paper, of which, like the preceding one, we cannot give more than a short abstract, in consequence of the author being unable to supply, in time, the number of diagrams required for its illustration.

ON SOME FACTS CONNECTED WITH THE SILICIFICATION OF ORGANIC BODIES. BY MR. E. CHARLESWORTH, F.G.S.

He commenced by expressing his assurance that, until a few days ago, he had not been aware that he should be expected to take a part in to-day's proceedings. However, he came forward in obedience to the call that had been made upon him, and would present a few remarks which he hoped would be such as would give satisfaction.

His object was not to treat of the general question of petrifaction, but of petrifaction under certain restricted circumstances. Silicification was neither more nor less than petrifaction with silex, a mineral which was to be found in a great variety of forms, but generally in the shape of common flint. The author here directed the attention of the company to a great number of diagrams which were suspended from the walls of the room, and describing thereupon flint in its natural state; besides various specimens of chalk and other substances in which it was found imbedded. He also pointed out some specimens of the silicification o. a class of organic remains which are popularly known by the name of fairy loaves or sea urchins *(Echinus.)* Another diagram represented a specimen of belemnite in the same state.

After referring to, and explaining, the different diagrams, he stated that the silicification of organic bodies was not at

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all connected with the amount of silex, but depended upon some other laws into which they had at present no insight. He described a portion of a jaw of a fossil reptile, *(the Mosasaurus Stenodon,)* which had been found in a chalk pit on the banks of the Thames, in 1835, and which had been found to contain something which greatly surprised him. He had the specimen placed in the hands of a lapidary, with instructions that he should saw him one of the teeth. When the instrument came to the middle of the tooth, something very hard arrested its further progress. The tooth was accordingly broken; and, on its falling in pieces, there was exhibited this remarkable feature, that in the very centre of the tooth was a piece of solid black flint, filling that portion of the pulp-cavity bounded by the expanded base of the tooth, as well as the extension of this cavity into the jaw; but there was no silicification of the investing bone, and no ostensible means of explaining the presence of the flint within the tooth, but on the hypothesis of its precipitation from a fluid, or of its having, in a viscid state, traversed the passage connecting the pulp-cavity with the great medullary canal of the jaw.*

The Rev. Dr. SCORESBY made a few observations on the excellence of the papers which had been read, and the importance of such meetings as the present.

The Noble CHAIRMAN addressed the meeting as follows: Ladies and Gentlemen,—We have listened to some observations respecting some remarkable phenomena; but, although we may indulge in high aspirations upon the subjects which have been brought before us, and in the hope of further discoveries following upon the patient investigation of facts,

* Mr. Charlesworth has given a full account of this specimen and the above interesting discovery, with figures, in the *London Geological Journal*, No. I., pp. 23—32, which lessens the regret we should otherwise feel in not being able to give this communication entire.

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yet I think there is enough in the pursuit of science which is well calculated to humiliate on the one hand, whilst it tends to elevate on the other. When we reflect on the discoveries of times past, and when we reflect upon what is now going on, and what we see around us, I believe the safest conclusion to be this—that there must have been in bygone times, that there is now in existence, and that there will be to the end of time, an existing power which it is beyond the reach of human capacity to discover. I hope you will excuse me for making these few observations on this very interesting occasion; but I must say, that I do not remember a meeting at which I have been more gratified by the facts and the observations which have been brought forward.

E. B. Denison, Esq., M.P., said—Ladies and Gentlemen,—I am sure you will all agree with me, that the least compliment that we can pay to the Noble Lord who has so ably and so kindly filled the chair this day, is to thank him for having presided over us. At the same time I must take leave to say, that when noblemen of his rank and station leave their homes and pursuits to attend meetings of this description, they bestow an inestimable value upon all who live around them.

A vote of thanks having been given to the Chairman,

The Earl Fitzwilliam acknowledged the compliment which they had paid him, and the meeting separated.

In the Evening, a Soirée of the Mechanics' Institution was held, to which the Members of the Geological and Polytechnic Society were invited. The meeting was addressed by Professor Phillips, and W. H. Leatham, Esq., John Parker, Esq., M.P., M. J. Roberts, Esq., C. Baker, Esq., Edward Charlesworth, Esq., and the Rev. W. Aspinall. The Chair was taken by E. B. Denison, Esq., M.P.

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE THIRTY-FIRST QUARTERLY MEETING, HELD IN THE EXCHANGE BUILDINGS, BRADFORD, ON WEDNESDAY, MARCH 25TH, 1846.

On the motion of JOSEPH TRAVIS CLAY, Esq., seconded by W. S. WARD, Esq.,

The Rev. Dr. SCORESBY, F.R.S., Vice-President, was called to the Chair, who commenced the proceedings by observing, that after the existence of the Geological and Polytechnic Society for so many years, it was now hardly necessary to explain very particularly its objects, though it might be useful, perhaps, to remind their friends that the objects of this association were, in a humble respect, analogous to the greater institution, the British Association, in many points of its character. The Society travelled abroad from town to town in the West Riding. Its leading objects, too, were similar; for one was the investigation of Geological subjects connected with the practical working of our mining system in the West Riding—a subject, of course, of great and important interest, and likewise bearing upon the economy and profitable enterprise of our mining operations; inasmuch as they all knew that it was requisite to bring a scientific knowledge of Geology to bear in this matter, with a view successfully to carry forward this enterprise. The leading object of this Society, then, was to arrive at information on

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this subject, with a view to the benefit of the community; and therefore they endeavoured to get at a correct knowledge of things beneath the surface of the earth. There was another department of this Society which gave them an opportunity to consider other subjects, in their place equally as important to society; he referred to the Polytechnic character of the institution, which enabled him to come that day to give them a few experiments on another important branch of science. They were anxious to cultivate these two leading and important branches: so that while they were inquiring on matters of Geological science, they might receive information from other gentlemen on subjects equally as important and interesting, but coming more particularly within the sphere of their various pursuits.

The Rev. Doctor then proceeded to deliver extemporaneously a communication

ON NEW AND EFFICIENT PROCESSES OF MAGNETIC MANIPULATION.

The subject of Magnetism, he said, had of late years become one of great importance. A very few years ago, Magnetism was thought little of, except for matters of experiment, or as processes needed for directing the navigator, the surveyor, or the miner. Now, however, it assumed a degree of importance that placed it among the most mighty agencies by which the Great Creator displays His eternal power and Godhead—agencies by which He controls the elements, and directs and binds them to His will.

Dr. Scoresby illustrated his novel method of charging magnets and steel bars with greatly increased power by two series of experiments. In the first, Mitchell's ordinary process of magnetizing a number of bars placed in opposition at their extremities was shown, in which the power conferred was

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insufficient when raised to the vertical position to maintain their own weight; whereas, on the experiment being repeated, but by *interposition of a thin plate of soft iron* between the magnet and the bars operated upon, and sliding the North Pole in advance over them as before, they were enabled to do so. These processes were, secondly, further displayed in the tractive power of supporting weights, the results of which were, that by the Doctor's method a horse-shoe piece of iron was enabled to sustain, when magnetized, nearly double the weight of that produced by any previously known process. A very powerful small magnet was exhibited, capable of carrying *ten times its own weight*, and very effective methods were pointed out of de-magnetizing bars, which were very ingenious.

At the conclusion of this communication, the following paper was read:—

ON THE COMPARATIVE ECONOMY OF VARIOUS METHODS OF APPLYING POWER FOR LOCOMOTION ON RAILWAYS, AND PARTICULARLY ON THE ATMOSPHERIC SYSTEM. BY WILLIAM SYKES WARD, ESQ., LEEDS.

In bringing to your notice the subject of Atmospheric Railways, I hope it may not be thought that I endeavour to introduce to you a chimerical speculation; for whatever may be the ultimate success of the promoters of the Atmospheric System, there is now little doubt that it is to a great extent practicable; and that if, in the infancy of railways, before the locomotive engine had been perfected as it is at present, the introduction of Atmospheric Railways would have been considered a great benefit to the community,—even at present we have the unequivocal evidence of the most eminent railway engineers, that the Atmospheric Railway is a great triumph to mechanism, the only doubt being whether it can be worked with practical advantage in a commercial point of view.

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We have also admissions by many engineers who are most strenuously opposed to the general introduction of the Atmospheric System, that there may be peculiar circumstances under which such system may be advantageously applied.

I will endeavour to state the subject on the broad principle that all human means of applying mechanical power are imperfect; that power cannot be transmitted without loss; and that with regard to locomotion on railways, the best method of investigation is to consider the various proposed systems *seriatim*, and to endeavour to investigate the loss of power to which each is subject.

I cannot, however, presume to bring any investigations before you in any other than a very imperfect state, nor have I had the opportunity of making more than the most trifling researches on the subject; but I hope to bring the researches of others to bear upon it, and to apply results which I have collected from very varied sources. In particular, I will mention the evidence taken and published by the Parliamentary Select Committee on Atmospheric Railways.

The application of ropes, as a means of communicating stationary power to railway trains, is perhaps the most economical method when the rope is not required to exceed a short length; but much power is lost when a great length of rope is used. The advantages of using ropes are, that the stationary power is most economically produced.

The losses attendant upon the use of ropes are, first, that power is lost in putting the rope into motion, or overcoming its *vis inertiæ;* secondly, that the rope must be supported on pulleys or rollers, the friction and *vis inertiæ* of which cause much loss; thirdly, that the train must be stopped every time it has to be attached to another length of rope, and therefore the momentum acquired by the train is lost.

These causes of loss of power are not practically great when high velocities are not required, but become so con-

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siderable as to preclude the application of tractive power by ropes, at velocities exceeding twenty miles per hour.

I have not attempted to estimate numerically each of such losses, but will refer to an example.

When the rope was employed between the Euston-square and the Camden-town stations of the London and Birmingham Railway, it was estimated by Mr. R. Stephenson, that only one-half of the power of the engine was usefully applied to the train.

All the methods of using ropes appear inevitably liable to considerable loss by the inaction of the stationary engines between the running of trains.

The various causes of loss of power in working locomotive, compared with stationary, steam engines, are—

That the greatest possible quantity of steam must be generated in the least possible space or dimensions of boiler, so that the heat produced from the fuel is not applied in so economical a manner as when large boilers are used.

That the whole power of the steam cannot be made available, as condensation is impracticable.

That the engine is confined in all its parts; the stroke of the cylinders and the connecting rods being too short, so that the friction is much more considerable than in a stationary engine.

That the steam cannot be made to do its full duty by being worked expansively, as in a stationary engine.

That as the valve openings must be wide, much steam is lost at each stroke, and rushes into the atmosphere without doing any duty.

That the pistons of the engine must work at a much greater speed than has been found advisable in the construction of stationary engines.

That the draft of the furnace must be produced at the expense of the power of the engine by contracting the blast

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pipe, thus preventing the free egress of the escape steam, and diminishing the effective pressure upon the piston.

That the boiler being much exposed, and passing through the air with great velocity, is subjected to considerable loss of heat.

That the engine, boiler, tender, stock of fuel and water, have to be transported at a high velocity, in addition to the useful weight of the train.

It is perhaps impossible accurately to calculate numerically the separate amount of each of the foregoing deductions from the power of the engine, but it has been practically ascertained, that in the aggregate they amount, in the case of average trains, to more than the amount of useful effect or duty obtained from the engine.

But when the trains are small in proportion to the engine, the loss becomes much more than 50 per cent.

The cost of the coke consumed by the locomotive is, on the average, at least twice that of the coal required for producing an equal amount of power with a stationary engine; so that the loss of power of the locomotive, as regards the cost of fuel, must be multiplied by two; so that out of an amount of power estimated in money, only 25 per cent. is usefully applied in working locomotive engines.

But the loss of power is by no means the greatest disadvantage attendant on the use of the locomotive engine.

The great weight of the engine, and the avoiding much play of the crank axle, by which it might in some measure escape from the impulse of the piston rods, renders it necessary that the bearing springs be very rigid; so that the machinery is liable to constant derangement from concussion.

Many parts of the engine are subject to much friction, under heavy weights and at high velocities; so that the wear and tear by friction is very considerable.

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The fuel is necessarily consumed under great draught, so that a very high temperature is produced, which rapidly destroys the copper fire boxes and brass tubes of the boiler.

The driving wheels of the locomotive engine are subject to great pressure, as well by the weight of the engine as by the tractive power exerted through them, and at times to considerable attrition on the rail.

All these parts of the engine are very expensive, and require frequent renewal. I believe the following are about the times of the average duration of the various parts of an engine doing average duty, but I hope to be corrected on the point. The fire box lasts from 3 to 4 years, a set of tubes from 9 to 12 months, the tire driving of the wheels about 6 months; the brasses require frequent renewal, and the fire bars are sometimes destroyed in one trip.

The weight of the engine and the rigidity of its springs not only injures the engine itself, but more than any other cause tends to displace and injure the rails; in fact, in narrowly watching a heavy locomotive passing at a high velocity, the wheels may frequently be observed to jump upon the rails.

The locomotive is subject to the foregoing losses and defects when travelling on railways of the best construction, and on a level, or more favourable gradients; but when a severe gradient occurs, the wear and tear of the engine is much increased, the weight of the engine itself absorbs the more tractive power when such power is the most wanted, and after a certain point of inclination, an ordinary locomotive is scarcely able to move itself.

Such liability to slip depends much on the state of the rail, which is most affected by a slight dew not amounting to rain, or by a frost such as frequently occurs in the morning during the spring and autumn.

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In such states of the rails a gradient as slight as 1 in 160 or 150 will sometimes reduce the speed of an ordinary passenger train as low as 10 miles per hour.

In estimating the various sources of loss of power on the Atmospheric system, it is ascertained both by calculation and experiment, that there is practically no material loss in the production of the prior exhaustion; that the loss of power by friction of the stationary engine itself will amount to about six per cent., as ascertained with respect to large stationary engines of the nearest similar construction.

The loss of power by friction of the air pump I have not precise means of ascertaining; it may amount to about four per cent., but most probably less, certainly not more. The friction of the engine and air pump at Dalkey appear, as taken by the indicator, to be about ten per cent.

There is, as shown by the experiments at Dalkey, considerable loss in opening the air pump valves, which, being large, shut with great violence, and are consequently fixed on the valve seats so as to require considerable power to open them, amounting almost to ten per cent.; but this amount does not arise from the absolute power required to open the valves, but because the valves being opened by the pressure of the air entering into or expelled from the pump, according to a well known hydrostatic law, require as much more force to open them by the pressure from the piston than by direct action as the area of the pump piston is larger than the area of the valves. At Croydon, for the sake of avoiding the concussion of the outlet valves, small valves are used of about three inches in diameter, and thirty in number at each end of the pump. I do not know how far this arrangement is preferable to that at Dalkey, but it appears to me that the valves at Croydon require very considerable power to open them, and that the air is much condensed before it makes its escape from the pump.

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I, however, hope I have effected some considerable improvement in this respect, by a method of working the valves of air pumps, by gearing (which I will afterwards explain) so as to avoid concussion, to give large air ways to both inlet and outlet valves, and work the valves by the direct power of the engine. I anticipate that this will save at least half the power otherwise lost in opening the valves, or about five per cent. of the power of the engine.

Another and somewhat unexpected source of loss is that the air, which by its expansion under exhaustion becomes cooler, rapidly takes up heat from the traction tube, and when again condensed in the air pump previously to being expelled into the atmosphere, gives out its heat so as to become very warm, and therefore requires much more power to expel it into the atmosphere. The heat of the air thus expelled sometimes exceeds that of boiling water.

Mr. Robert Stephenson appears to have investigated the loss by the opening of the pump valves, and of the heating of the air together, by means of the indicator; such results vary considerably at the different degrees of exhaustion. The maximum appears to be about 17 per cent., but I conceive a mean of 15 per cent. to be rather too high. The most important loss, however, arises from the leakage of air into the tube; but this appears, after the most careful experiments, and on a fair mean of workings at Dalkey, to be very much less than could be anticipated, being at the rate of about four cubic feet of air at the pressure of the atmosphere per second, including leakage of air pump, valves, close connecting main, and traction tube—the leakage of the pump valves and of the connecting main being greater than that of the traction tube. The greatest amount of leakage observed at Dalkey, when the apparatus was out of order, was only seven cubic feet per second. But I am informed that at Croydon the leakage is now extremely small, not proportion-

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ately half as much as at Dalkey. This is corroborated by the fact, that at Dalkey a higher vacuum than 25½ could seldom be obtained, whilst at Croydon I have seen 27½ inches easily obtained.

It is also remarkable that the absolute quantity of air which enters the tube is nearly constant at all pressures above six inches of the gauge, evidently resulting from the fact, that the higher pressures close the valve more perfectly than the lower ones; but the higher the gauges the more important the loss by leakage becomes; thus at 15 inches of the gauge or half vacuum, the four cubic feet would expand to eight, and require the action of eight feet of pump space to remove or overcome such leakage; at twenty inches, or 2-3rd vacuum, the four become twelve feet, and require twelve feet of pump space; and at twenty-five or 5-6ths vacuum, become twenty feet of rarefied air, and require the exertion of twenty cubic feet of pump space.

Therefore, if the leakage of three miles of pipe be six cubic feet per second, the pumps capable of removing 120 cubic feet per second, at a vacuum of twenty inches, the six feet become eighteen; the loss is, therefore, fifteen per cent. of the action of the pumps. But the loss by leakage is very small during part of the prior exhaustion, and is proportionally diminished as the train proceeds and shortens the length exposed to leakage.

The friction of the travelling piston amounts to about 35 lbs. out of 1,760 lbs. pressure, or about two per cent. of the power, as carefully ascertained by the experiments of M. Mallet.

There is another source of loss of power which has been the subject of much and very ingenious calculation and discussion; I allude to the friction of the air in the pipe. From the data given by the transmission of gas and of water through tubes, it was found that the friction increased according to

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the square of the length, and it was predicted that in employing a traction tube three miles long, a velocity of twelve miles per hour could not be attained at three miles from the air pump, on account of the resistance of the friction of the air in the pipe: but the parties who made such calculations appear to have overlooked the fact, that as air in tube becomes more rare, the resistance is diminished, probably in the ratio of the squares of the density, and also that air may offer less resistance to the action of pumping it out of a tube than to that of forcing it through; in like manner as sand may be poured out of a tube, but is only with great difficulty forced through.

But practice is better than theory, and the triumphant speeds obtained at Croydon prove that the friction of the air in the tube does not prevent the attainment of a high speed, but is merely a source of the loss of some power, inasmuch as the barometric gauge at the end of the tube stands somewhat lower at the end of the tube than in the engine-house, I believe about two inches, thus showing a loss of about 10 per cent.; but this amounts to little more than a retardation during the prior exhaustion, and also to some extent during the running of the train, and is rapidly diminished as the piston advances in the pipe, so that five per cent. may cover the amount of the loss by friction of the air in the pipe.

We have, therefore, the following losses per cent.;—

Friction of engine and pump	10
Adhesion of pump valves, and heating of air	10
Leakage	15
Friction of travelling piston.....	2
Friction of air in traction tube	5
Together	42

But the three latter items are deductions from the residual power after 20 per cent. has been deducted; their amount

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must therefore be increased in the ratio which 100 bears to 80, so that the loss becomes 47½ per cent.

There is also the loss of fuel in keeping the steam up during the time the engine is inactive. The best stationary engines may be worked at a consumption of 5 lbs. of coal per horse power of 60,000 per hour working constantly, but if the engine be worked only a portion of the time, and remain inactive during intervals, having the steam still kept up, the expenditure of fuel during the working will be after the rate before stated, 5 lbs. per horse-power per hour; during the intervals, fuel will be required at the rate of 2½ lbs. of coal per horse-power per hour.

These data are fully confirmed by the evidence of Mr. Bergin, who has part of the management of the Kingstown and Dalkey Atmospheric Railway, both as being the general opinion of engineers, and as confirmed by the results of eleven months' working of the engine there.

On the basis of the results shown by these calculations, I anticipate considerable advantage may result from the system of exhaustion, which I have patented,* by which the power constantly exerted by comparatively small engines may be accumulated during the intervals between the running of trains, and afterwards made available in assisting the engine in exhausting the tube.

In addition to the loss of power whilst the engine is working, the Atmospheric system, as hitherto applied, must be charged with a quantity of fuel burnt without producing any power; and unless some method be adopted for accumulating power during the intervals, this lost fuel will in some cases amount to more than twice the amount of fuel usefully burnt, and even in very favourable cases, to half the amount of the fuel usefully burnt.

I, however, hope that my method of accumulating power

* See specification annexed.

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will enable us to reduce the fuel wasted during inaction, to from 15 to 20 per cent. of the amount of fuel usefully employed. And I will now remark that all other systems of locomotion, by stationary power, are subject to the like loss of fuel during the period the engine is inactive, as occurs in the Atmospheric system, as hitherto applied; indeed, more so, for on the Atmospheric system the power is accumulated during the production of the prior exhaustion, but the rope system does not admit of any accumulation. The locomotive engine must also be charged with some loss of fuel during inaction; but this will perhaps not exceed 10 per cent., as the fuel does not consume very rapidly, when not urged by the blast pipe.

The account of fuel and power between the locomotive and the atmospheric system, will, therefore, stand as follows, each system being supposed to carry loads of 75 tons, or about 15 passenger carriages on a level, and two trains per hour:—

ON THE LOCOMOTIVE.

200 of money, represents	100
The loss by locomotive equals the power usefully employed	50
Power usefully employed	50

ON THE ATMOSPHERIC AS HITHERTO USED, THE TRAFFIC BEING TWO TRAINS PER HOUR.

200 of money, represents 100 loss during interval, and 100 of power generated	100.0
Losses by friction of engine, by air pump, heat of air, leakage, friction of air, and travelling piston	47.5
Power usefully employed	52.5

ON MY SYSTEM.

240 of money, (after deducting 20 per cent. for lost fuel,) represents	200 of power.
Losses at 47.5 per cent. as before	95
Power usefully employed	105

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This being reduced according to proportion between 200 and 240, gives 87.5.

Thus the Atmospheric system, as hitherto used, has the advantage of the locomotive in consumption of fuel in the proportion of 52.5 to 50.

My system may have the advantage over the locomotive in consumption of fuel as 87.5 to 50.

But the results of such calculations would materially vary, according to the data of the weight and of the number of trains per day; for the loss on the locomotive systems becomes very much greater when the train is much smaller than 75 tons or 15 carriages; and the loss on the Atmospheric system, as hitherto applied, that is, without reservoirs, is very great when few trains are run.

Again, when a heavy traffic of goods has to be taken over a level or very slight gradients, the locomotive will prove the most economical; but when the gradients become so severe as to cause slipping of wheels, and require assistant engines, I doubt not the Atmospheric system will afford great advantages.

The Atmospheric system also promises great advantages in the rapid transit of passengers over a line of moderate length, that is, 30 to 40 miles, which would easily admit of a single line being used.

A vote of thanks was afterwards unanimously passed, on the motion of Dr. ALEXANDER, of Halifax, to the Chairman, for his services in the chair, and his still more valuable contribution that day to practical science—a contribution, like many other kindred discoveries, so remarkable for its simplicity and easy application. The Society then adjourned to dinner, and there was no further business in the evening.

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE THIRTY-SECOND QUARTERLY MEETING, HELD IN THE CONCERT ROOM, YORK, ON THURSDAY, THE 23RD JULY, 1846.

The Right Hon. the Earl FITZWILLIAM, F.R.S., President, in the Chair.

The Noble Chairman stated that Dr. LYON PLAYFAIR was to have read a paper at this meeting on "The Chemical Effects of Summer Fallows," but having lately taken unto himself a partner, he was not able to attend on the present occasion. He (the Chairman) should, therefore, call upon the Rev. Dr. SCORESBY to read his paper

ON THE CONSTRUCTION AND PERFORMANCES OF THE EARL OF ROSSE'S GIGANTIC TELESCOPE.

The Rev. Dr. SCORESBY, after a few introductory observations, remarked that he might have occasion to refer very briefly to the principle of the instrument as necessary to the illustration of his subject. For the information of those who might not be aware of the construction of the telescope, he would observe that the principle upon which it acted was this,—it simply depended upon the property of a convex glass and of concave reflectors, which produce an image at their focus. For instance, if he had a magnifying glass, and admitted the light through that, more particularly in the way of the *camera*

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obscura, there would be an image of the object formed at the other end. That image would be in proportion to the focal length of the glass, so that the telescope which had the longest focal distance would magnify the best. It is the area or surface of the glass, or the metal, which gives the quantity of light, but a speculum of one-inch size will produce the same magnifying power if the focal length is fifty-four feet, as the six feet telescope of Lord Rosse. The only other thing with reference to the principle was the examination of the object, which can be shown by a simple experiment with a lantern or candle. If, for instance, he placed a magnifying glass near a candle or a lamp, he would have thrown on a piece of paper the image of the candle inverted. The forms of telescopes are very various, and the Earl of Rosse has greatly improved the previous practice with reference to the construction of telescopes. One of the most striking things was his very fine invention for the casting of a speculum of large magnitude. The substance of which the speculum is made was a mixture of tin and copper, thus forming an alloy of the most brittle substance known; hence the difficulty of casting speculums so that they would bear the abrasion of polishing and grinding. Not long since he met with an Irish gentleman at the Earl of Rosse's residence, who had received a gold medal from the Society of Arts, for the completeness with which he had constructed a speculum of nine inches in diameter. That gentleman told him that he had made thirty different castings, and out of these he had obtained only two perfect specimens. The Earl of Rosse had cast four speculums of six feet in diameter instead of nine inches, and weighing three tons instead of fifteen or twenty pounds; out of these he got three perfect castings, one of which, however, was unfortunately afterwards spoiled by the carelessness of a workman. Connected with the preparation of the metal there is a matter of interest to the

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chemist. In pouring the metal into the mould, if it is too hot the experiment will fail, and also if too cold. There is an intermediate degree of heat to which the metal should be reduced, and this might be obtained by the following chemical test. All chemists are aware that on the melting of metals there would be an oxyde formed on the surface. But they were also aware that a piece of wood of a carbonaceous substance would reduce that oxyde and convert it to metal. This was the means which the Earl of Rosse had adopted to reduce the oxyde, and the moment that effect was produced, the metal was in a fit condition to pour into the mould. Great difficulty had also arisen with respect to the grinding and figuring of the speculum; but Lord Rosse had also succeeded in overcoming this obstacle by the contrivance of a simple piece of machinery, whereby he was enabled to perform the operation under an equal temperature, which was most essential to the perfection of the speculum. Having described the manner in which this great instrument is fixed for the purposes of observation, Dr. Scoresby proceeded to give an interesting account of its performances. The instrument was first brought into operation in the spring of last year, and in the course of one month there were no less than forty-three nebulæ resolved into distinct stars by its aid, those nebulæ having hitherto appeared, through other instruments, to be merely obscure specks. This was a fact which led him to apprehend that those who were advocates of the nebulæ theory would, ere long, abandon the idea of their being luminous matter in the process of being formed into suns or worlds. Dr. Robinson, of Armagh, stated that, with Lord Rosse's telescope, stars which Herschel described as of the fifteenth magnitude, were as brilliant as stars of the first magnitude seen by a telescope of three or four feet in length. He next referred to the indescribably gorgeous appearance of the surface of

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the moon as seen through this gigantic telescope, and to the discovery of a large number of craters thereon, some of which were as minute as the blunted point of a pin, and as distinct as if cut with a diamond, whilst others had the appearance of being surrounded by walls or rugged rocks, which had probably been formed by the emission of volcanic matter. To give a popular idea of the powers of this instrument, he would observe that any building the size of York Cathedral, or even less, might be distinctly seen, if there were such a building on the surface of the moon. It was pretty certain that the moon was not inhabited; that there was not even "a man in the moon;" at all events, if it were so, the inhabitants must be pigmies in stature, or altogether of a different nature from ourselves. It was concluded also that there was no water on the surface of the moon—no meandering streams or rivers, as in this country—and no extensive lakes, as in America. In short, the surface of the moon presented the appearance of a world in ruins. Such was a brief outline of the discoveries which had already been made, and there were ample grounds for anticipating far greater results than those which had been realised.

The Venerable Archdeacon WILBERFORCE moved a vote of thanks to Dr. Scoresby, which was carried unanimously.

The CHAIRMAN next called upon the Rev. W. THORP, the Secretary to the Society, to read his paper, entitled

ILLUSTRATIONS OF THE GEOLOGY OF THE YORKSHIRE COAL FIELD.

He observed that the Coal-field of Yorkshire is one of the largest, and is hitherto less exhausted of its minerals than any other in Great Britain. The towns of Sheffield, Bradford, Leeds, Halifax, Huddersfield, and Barnsley owe

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their existence to them. About 4,000,000 tons are annually raised, and owing to the want of a cheap and quick communication to the sea, on the one hand, only comparatively few tons are annually exported, while Northumberland and Durham export 7,000,000 tons; and, on the other, without any connection with any main trunk lines of railway of the country, as the Sheffield and Manchester, or Midland, the Coal-field from Wakefield to near Sheffield is completely cut off from all cheap and quick modes of transit. Some of the lower portions of the strata of this Coal-field are prolonged into Derbyshire, and others into Lancashire. The vertical thickness of the whole strata is about 1,200 yards, which may be divided into three parts. The lowest portion, about 200 yards thick, does not produce coal of any very great value. The middle portion, prolonged into Derbyshire, is about 600 yards thick, and contains the most productive and richest number of coal seams. The upper portion, about 300 yards thick, consists entirely of coarser arenaceous beds, and the coal beds do not, as lower in the series, cover large areas.

The Rev. Gentleman proceeded into a minute detail of the various seams of coal, their position, quantity, and quality, which he illustrated by reference to various sections, and mentioned the fact that, in the lowest portion, although the Coal was of inferior quality, yet there was no portion of the Coal-field more curious in its Geological relations, and particularly with regard to a considerable diversity of marine shells, which are found in several parts of the Coal-field near Sheffield, Halifax, &c.

The average vertical thickness of solid coal in Yorkshire is from 90 to 100 feet, and Humboldt asserts that in the temperate zone the growth for 100 years of the forests upon any given part would not cover it seven lines (not half an inch) in thickness with carbon; and therefore in order to account for

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the enormous quantities and sizes of the plants which compose the Coal strata, we must inquire into the forces which are concerned in the organization of plants. A greater quantity of carbonic acid in the atmosphere, together with an increase of terrestrial temperature, have been assigned as sufficient causes for this luxurious vegetation; but from the researches of Dr. Draper, Professor in the University of New York, light, or rather the tithonic rays, are the active agents in the growth of all vegetation. That gentleman had suggested that the sun is one of those periodic stars, the light of which undergoes secular changes; that for a series of years or of centuries, it increases in brilliancy, and then fades away; that, affected by this, the rate of vegetable growth, the character of animal life, the constitution of the atmosphere, is simultaneously changed in all the attendant planets. And among the stars these periodic variations do take place. It signifies nothing that these periods are short. In the constitution of the universe, no value is attached to time. With men, whose period of action is embraced in a few years, the different events are circumscribed by measured spaces. But in the administration of the universe, the case is different; in eternity there are no limits of duration, and time can be expended without loss or detriment. In the revolution of one system of stars round another, millions of centuries are required, and they are consumed. And in the case we are considering, the glowing and fading away of one star may be accomplished in a few days, but inconceivably greater periods may be wanted for the same events in another. Even philosophers are too prone to believe that, by the short spaces of human life, or the history of nations, they can mark out periods in eternity; but whether we consider the scale of space, or of time, on which the universe is constructed, we see that our minds are so constructed as to be equally unable to appreciate either extremity; that we can

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attach no just idea to what is either infinitely great or infinitely small; and that, therefore, our views do not always justly apply in natural events. Of one thing we may rest assured, that no matter how great the periods that may be required for the phenomena of the universe to transpire, there has been, and will be, time enough for their endless repetition.*

At the conclusion of the paper,

Professor PHILLIPS congratulated the Society on hearing the result of many years of hard work among the Coal-fields in Yorkshire; and he expressed a hope that Mr. THORP would publish the result of his experience more at length in the transactions of the Society.

Dr. BUCKLAND, (Dean of Westminster,) offered some remarks in favour of the theory that Coal was a vegetable construction. He affirmed it to be the unanimous opinion of all competent persons that the Coal-fields of this county were derived from vegetable origin, and composed of vegetables grown upon the spot; and after seeing Mr. Thorp's sections, he was himself more and more confirmed in that opinion. He concluded by expressing admiration of the labours of Mr. Thorp, and also eulogised the efforts of Professor Phillips in the same pursuits.

Sir R. I. MURCHISON dissented from the opinion that the Yorkshire Coal-field was a deposit of jungles, forests, peat bogs, and masses of vegetables grown upon the spot. He argued that it was a deposit of matter drifted from a distance; and he asserted this after having accompanied Mr. Thorp in his travel. To a large portion of the tract under consideration, he could bear ample testimony as to its accuracy. The Coal-fields of the North of England, such as Newcastle and

* The entire paper, of which this is an abstract, will appear in Mr. Thorp's forthcoming volume on the Yorkshire Coal Field.

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Durham for instance, which he had lately examined, were most certainly of the latter description. In conclusion, he complimented the author upon his distinguished labours.

Professor PHILLIPS begged to observe that when the facts or phenomena were self-evident, Geologists were willing to agree; but where they offered somewhat doubtful characters, then they were compelled to differ, and could be allowed to do so. The fact was that he thought to a certain extent both theories were correct. In some instances, Coal-fields were derived from vegetables which had grown on the spot; and in others, they were the accumulation of vegetable substances transported from other localities by the action of floods.

Earl FITZWILLIAM said he thought the students of Geology were too apt to draw hasty conclusions, as they were ignorant of the mighty power which had been at work in the formation of the crust of the earth.

After a vote of thanks to the Noble Chairman by Dr. BUCKLAND, the meeting concluded.

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE ANNUAL MEETING, HELD IN THE CUTLERS' HALL, SHEFFIELD, ON WEDNESDAY, OCTOBER 28TH, 1846.

The Right Hon. the Earl FITZWILLIAM, F.R.S., President, took the Chair.

His Lordship said, the first proceedings in point of order, or, rather, in point of custom, would be the election of New Members, and then the reading of the Report; after which, the constitution of the Society authorized the election of Officers; and those gentlemen who had previously held office were eligible to be re-elected; but it was necessary that this form should be adhered to, as they were only elected for one year.

The Rev. WM. THORP then moved, and Mr. THOMAS WILSON seconded, that the following gentlemen be admitted Members of the Society:—

The Hon. and Rev. W. HOWARD, of Whiston;
The Rev. WILLIAM MASON, of Normanton;
JAMES YATES, Esq., F.R.S., Norton Hall, Derbyshire.

The SECRETARY then read the following Report for the past year:—

REPORT OF THE COUNCIL OF THE GEOLOGICAL AND POLYTECHNIC SOCIETY OF THE WEST-RIDING OF YORKSHIRE, PRESENTED AT THE EIGHTH ANNUAL MEETING, ON THE 28TH OF OCTOBER, 1846.

The progress of the Society during the two years past, and its present condition and prospects, may be considered satisfactory and encouraging.

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Owing to the change of the office of Secretary, the printed transactions of the Society, as well as the monies due to it, had become considerably in arrears; but the Council are happy to state that copies of the Reports hitherto deficient, (as far as the Doncaster Meeting, October, 1845,) are now ready for the Members; the debts of the Society are all paid off; and sufficient money is collected to permit the affairs of the Society to be conducted with ease and satisfaction.

It is most satisfactory to the Council to state that the objects for which the Society was instituted continue to excite the greatest interest in all the towns to which the visits of the Society are made; that the Meetings have, with only one or two exceptions, been numerously attended; and that an increased number of most valuable communications have been recently made, which will be found in the published reports alluded to.

In consequence of these Reports, it is unnecessary to give more than a bare enumeration of the Papers that have been read, which are as follow:—

"On the Spontaneous Decomposition of Fat," by Wm. Lucas, Esq.

"A Description of Fossil Trees found in Erect Positions in the Carboniferous Strata," by E. W. Binney, Esq.

"On the Construction of an improved Anemometer," by Benjamin Biram, Esq.

"On a Fossil Nautilus, found near Halifax," by Dr. Inglis.

"On the Principal Faults in the Yorkshire Coal Field," by the Rev. W. Thorp.

"On the Advantages of Mechanical Force over the Power of Rarefaction in Ventilating Mines and Buildings," by Mr Fourness, of Leeds.

When it is considered that the amount of human life sacrificed annually by explosions in coal mines is very enormous, and the expense of Mr. Fourness's machine is comparatively

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trifling, and its utility being fully proved, it is very extraordinary that it is so little in use. It is hoped, however, that the attention of persons connected with mines will be called to the subject by the publication of this valuable communication.

"On the Causes of the different Rates of Mortality in some of the most populous Towns in the West Riding of Yorkshire," by the Rev. W. Thorp.

Sheffield and Leeds have exactly the same rates of mortality, 1 in every 38 persons dying annually in each place. Why is this? Huddersfield and Halifax have likewise exactly the same rates of mortality, 1 in every 48 persons dying. Why are these rates exactly alike? And why are the two latter places so much more healthy than Leeds or Sheffield, or even than the agricultural districts of Doncaster, Thorne, Selby, Pontefract, and Goole? Barnsley and Wakefield have likewise the same rates of mortality. Bradford is much more healthy than Leeds or Sheffield. Why is this? The districts of Glendale, Bellingham, and Haltwhistle, about 15 miles distant from Newcastle, are just twice as healthy as Newcastle itself, 1 in 68 dying in these districts, and 1 in 34 in Newcastle. Liverpool, with its gentle slope to the Mersey and fine sea air, is the most unhealthy town in England; while the oölite districts of Helmsley, Pickering, and Malton, are the most salubrious parts in Yorkshire. The Paper professes to account for these differences.

"On Vibrations producing Sound," by W. Sykes Ward, Esq.

This Paper treats of one of the most profound branches of the physical sciences, and discusses the question whether sound is produced and propagated by undulatory or by progressive motion.

"On the Mutual Relations of Animal and Vegetable Existence," by Dr. Heaton.

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This most excellent Paper treats, in addition to what its title would lead us to expect, of some of the more recondite phenomena of the nutrition of organized beings.

"On Lime, and its Uses in Agriculture," by Henry Briggs, Esq.

This valuable Paper not only shows the uses of lime and the quantity per acre required, but also affords the results of some costly analyses of lime from various parts of Yorkshire.

"On the Remains of Microscopic Animals in the Rocks of Yorkshire," by Professor Phillips.

This Paper indicates the characters and species of the amazing number of infusoria found in all the more compact and stratified rocks of Yorkshire.

"On some peculiar states of Water at High Temperature, and upon the Freezing of Water in red hot vessels," by Wm. West, Esq., F.R S.

This Paper is explanatory of the experiments performed by Mr. West, which excited the highest degree of interest, and were performed with the greatest skill.

"Observations on the Currents and Phosphorescence of the Atlantic," by the Rev. Dr. Scoresby, F.R.S., &c. &c.

"On some interesting Communications made at the recent Meeting of the British Association at Cambridge," by the Rev. Dr. Scoresby.

"On the Fossil Animal Exuviæ of the Yorkshire Coal Field," by Mr. Denny, A.L.S.

The author gives an account chiefly of the animal remains preserved in the public and private collections of specimens in and near Leeds.

In conclusion, the Council desire to express their warmest acknowledgments and gratitude to their enlightened and most noble President for his very kind attention to the Society, and especially for so repeatedly presiding over their Meetings;

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and while they perceive that the Society yearly advances in public estimation, they express their conviction that it has only to persevere in the course hitherto pursued to render its utility more universally known and distinguished.

STATEMENT OF THE RECEIPTS AND EXPENDITURE,

From 1st January, 1846, to 28th October, 1846.

Dr.	£.	s.	d.	Cr.	£.	s.	d.
To Subscriptions—				By Stationery, &c.	0	7	6½
From 3 Members for 1840..£1 11 6				,, Advertising Meetings	7	19	0
,, 5 ,, 1841.. 3 5 0				,, Salary of Assistant Secretary	50	0	0
,, 21 ,, 1842.. 13 7 0*				,, Rent of Museum Room, &c., for one year and a half	45	0	0
,, 42 ,, 1843.. 26 17 6*				,, Collecting Subscriptions, &c.	4	14	0
,,160 ,, 1844.. 64 11 6*				,, Postages	1	0	5
,,103 ,, 1845.. 66 10 6*				,, Expenses of Meetings	4	13	9
,, 6 ,, 1846.. 3 18 0				,, Printing Reports, &c.	22	0	0
—180	1	0		,, Expenses of fitting-up Geological Cases in New Room	23	15	0
				,, Philosophical Society, towards erecting New Gallery	15	0	0
				,, Sundry Expenses	0	11	0
				,, Cash in Treasurer's hands	5	0	3½
£180	1	0		£180	1	0	

Dr. Heaton moved "that the Report of the Council, together with the Statement of the Accounts, be received and printed." He congratulated the Society on the very satisfactory Report which he had the pleasure of moving. The statement of the financial affairs of the Society was most gratifying, and clearly showed that the esteem in which the Society was held was gradually increasing; and, from the nature of the knowledge which it purported to communicate, he was sure that it deserved to rise higher and higher, and he felt no doubt but that it would do so. He was glad that their efficient Secretary, Mr. Thorp, would, in future, be relieved from a great portion of his hitherto very laborious duties; and thus the efficiency and usefulness of the Society would be preserved and increased.

Phineas Beaumont, Esq., seconded the motion.

* A deficiency is apparent in these amounts, which is occasioned by £1 11s. 6d. having been deducted by some Members for not receiving their Reports.

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The Rev. Dr. SCORESBY moved "that the following noblemen and gentlemen be Officers and Council for the ensuing year:"—

President.

EARL FITZWILLIAM, F.R.S.

Vice-Presidents.

DUKE OF NORFOLK.	T. W. BEAUMONT, ESQ.
EARL OF EFFINGHAM.	J. SPENCER STANHOPE, ESQ.
EARL OF DARTMOUTH.	G. LANE FOX, ESQ.
LORD WHARNCLIFFE.	J. W. CHILDERS, ESQ.
LORD STOURTON.	EDWARD B. BEAUMONT, ESQ.
VISCOUNT MILTON.	R. M. MILNES, ESQ., M.P.
HON. W. S. LASCELLES, M.P.	GODFREY WENTWORTH, ESQ.
SIR F. L. WOOD, BART.	W. BENNETT MARTIN, ESQ.
SIR W. B. COOKE, BART.	JAMES G. MARSHALL, ESQ.
RIGHT HON. CHAS. WOOD, M.P.	MICHAEL ELLISON, ESQ.
REV. DR. SCORESBY, F.R.S.	T. D. BLAND, ESQ.
REV. SAMUEL SHARP.	PHILIP D. COOKE, ESQ.
REV. THEOPHILUS BARNES.	WILLIAM WEST, ESQ., F.R.S.

Council.

HENRY BRIGGS, ESQ.	CHAS. MORTON, ESQ.	AMBROSE BUTLER, ESQ.
J. T. CLAY, ESQ.	DR. WM. ALEXANDER.	DR. CHADWICK.
HENRY HOLT, ESQ.	J. M. STANSFELD, ESQ.	EDWARD WAUD, ESQ.
THOMAS WILSON, ESQ.	J. W. LEATHER, ESQ.	DR. HEATON.

Honorary Secretary.

REV. WILLIAM THORP, Womersley Vicarage.

Assistant Secretary and Treasurer.

MR. HENRY DENNY, A.L.S.

Honorary Curators.

T. W. EMBLETON, ESQ., AND J. G. MARSHALL, ESQ., F.G.S.

Auditors.

BENJ. BIRAM, ESQ., AND G. W. CHAMBERS, ESQ.

Mr. Alderman DUNN seconded the motion, and said he hoped he might be allowed to say a word in reference to the Report. It was stated therein that, with one or two exceptions, the Meetings of the Society had been well attended. As a native of Sheffield, he could not but express his deep sorrow and sincere regret that this town should be determined to hold so pre-eminently unenviable a notoriety in not attending these Meetings in a proper manner. He hoped the

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Council would give Sheffield one trial more; and that in future the Meetings of this Society would be attended as they deserved to be.

Mr. WILSON moved and Mr. BIRAM seconded a vote of thanks to Dr. William Alexander, of Halifax; Thomas Pitt, Esq., of Huddersfield; Phineas Beaumont, Esq., Sheffield; and George C. Walker, Esq., Doncaster, for their exertions in behalf of the Society in acting as Local Treasurers; and that they be requested to continue their valuable services.

The Rev. Dr. SCORESBY was now called on by the Chairman to read his Paper

ON SOME INTERESTING COMMUNICATIONS RECENTLY MADE AT THE MEETING OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, HELD AT SOUTHAMPTON.

Dr. SCORESBY then came forward, and said the four subjects he intended to introduce to the meeting, if he should have time, were—

1. Some account of the Decomposition of Water into its Constituent Elements by Heat, and *vice versa*.
2. Some account of the Tube across the Menai Straits.
3. Observations on Professor Schonbëin's Explosive Cotton.
4. Some notice of Artesian Wells, with the new mode of Boring them, as suggested by Mons. Fauvelle.

The first theory had been advanced by Professor Grove, at the discussions of the Chemical Section for the Advancement of Science, at Southampton, who had contrived an apparatus called the "Euidiometer," by which he could collect the gases, and make satisfactory experiments upon them. It was asserted by Professor Grove that the same process which would combine gases would also separate them. It was a well-known fact that water was composed of oxygen and

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hydrogen, from a chemical union of which it can be easily formed. No success had attended any attempt to collect both oxygen and hydrogen into one experiment, without having been absorbed by any other substance. The process introduced by Professor Grove was clearly elucidated by diagrams, and consisted in the introduction of two platina wires into the lower part of a glass tube, hermetically sealed and filled with water, from which the atmospheric air had been expelled by the process of boiling. The wire is then heated in an immense degree by the galvanic current, and the intense heat has the effect of decomposing the water, and the gases ascending to the top in large bubbles are collected at the other end of the tube. The decomposition was produced by the action of the galvanic fluid. The result was precisely the same by the hydrogen blowpipe. Dr. Scoresby said it was necessary that the water used should be distilled, or the result would not be the same. The plan was somewhat analogous to that which had been laid down by Dr. Priestley, though not altogether so. The impression left on the mind of the Association at the time that it was introduced was, that the experiment was singular, conclusive, and interesting.

Dr. Scoresby next introduced the subject of the tunnel tube across the Menai Straits, which was proposed to be 450 feet in length. The question to be decided in this matter was, whether a tube of iron could be made to bear itself when suspended on two points, and also carry a railway train. The success of the experiment seemed to depend on this fact; and, from the tests which had been made by Mr. Eaton Hodgkinson, as to whether a tube or mass of iron, set edgeways, or in any other form, stretching to a considerable distance, would have the same relative power of support with a smaller piece of iron, it had been ascertained that the frames of iron were arithmetically proportional to their relative dimensions. Having thus tested the capabilities of the iron,

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it was proved that there would be no difficulty or essential hinderance to having a tunnel stretched from Calais to Dover.

The next subject alluded to was Professor Schonbëin's invention of Explosive Cotton, which, though not in the nature of powder, yet appeared to possess all its properties. Explosive cotton has formed the subject of an interesting lecture by Professor Grove, which was read at Southampton, and which also contained a history of gunpowder. Substances, he said, of the same explosive nature as gunpowder, were known in China in very remote ages. Mention was made in works in the Chinese language, and also in works in the Arabic tongue, of ancient date, of substances of an explosive nature resembling gunpowder—many centuries, indeed, before it was known in Europe, which was about the middle of the fourteenth century. A Hindoo lawgiver also mentioned something approximating to fire-arms; but the Hindoos appeared to have confined this invention to their own country, till after gunpowder had been used in Europe many years. Gunpowder was composed by combining combustible substances with a substance that supplies abundance of oxygen for the support of combustion. This was formed in a vast variety of ways. Gunpowder might be produced from powdered zinc, which, being combined with nitre, would form a very powerful kind of gunpowder. Iron filings might be so converted as to form the same explosive substance. Nitre, it appeared, was an essential element in the explosive substances used by the Chinese, and also in the celebrated Greek fire used in the wars between Greece and Rome. The gun cotton of Professor Schonbëin was like our common cotton; and the portion exhibited at Southampton was glossy, fuzzy, and flocky.

The principal advantages of the explosive cotton over gunpowder are, that it is produced at one-half the expense; less smoke is evolved; it leaves but little, if any, residuum;

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can be used after wetting; and the noise is also considerably less. The preparations were nitrate and sulphuric acid. Dr. Scoresby said that the cotton might ultimately be applied instead of steam to machinery, inasmuch as one difficulty would be obviated, namely, the corrosion of the cylinder into which gunpowder was made to act.

The Rev. Doctor concluded by remarks on Fauvelle's plan of making bore-holes for minerals and Artesian wells for water. At Perpignan, M. Fauvelle had bored by his mode a depth of 560 feet in fourteen working days of ten hours each; and this he did beside a place where the attempt had been made by the ordinary mode during eleven months in vain. M. Fauvelle had not tried to get through any extraordinary obstruction; but if he met with one, he took up his apparatus and tried elsewhere. An Artesian well had been tried at Southampton, where, by the old mode, a depth of 1200 feet had been obtained at a cost of £20,000, or nearly £16 per foot; whereas by M. Fauvelle's system, four feet might be penetrated in an hour. Dr. Scoresby proceeded to notice the Chinese mode of boring, and recommended as an addition to it a plan something like that of the patent corkscrew. He anticipated from these operations a great improvement in the processes of boring, which would be a very great advantage to a mining country like ours.

Wm. Sykes Ward, Esq., of Leeds, said with regard to the first subject mentioned by Dr. Scoresby, platina was almost the only substance that would bear sufficient heat to resolve water into its elements. He regretted that the secret of the gun cotton had come out prematurely; and the exhibition of it at the British Association, and the statement of the fact that it was cotton, had no doubt conduced to this. Six English chemists, he believed, discovered it almost simultaneously, but kept it secret, that they might

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not injure Schonbëin. He (W. S. Ward) had prepared gun cotton by soaking fine cotton in an equal mixture of sulphuric and nitric acid. The acid was then washed out of the cotton with water, and it was dried; but this should be done at some distance, for at three or four feet from the fire a quantity exploded in his hand, though it did not burn. He thought the preparation of it must be expensive, for it required a liquid ounce of each acid to prepare one ounce of the cotton. Four grains of the cotton sent a pistol ball through an inch board and flattened it. It required eight grains of gunpowder to do the same. In each case the noise of explosion was about the same, though that of the cotton was rather more like the crack of a whip. In mining, the cotton would be very useful; for the effect of the shot might be ascertained at once, whereas it was necessary to wait three quarters of an hour to allow the smoke of powder to disperse. He doubted the applicability of the cotton to machinery, because the explosion was so transient. It opened, however, an interesting inquiry as to the effect of these acids on vegetables. He understood that sawdust might be applied in the same way. He thought there would be great difficulty in the use of this cotton in artillery; for percussion would cause the cotton to explode, and it therefore might be exploded by the friction or shock of heavy cannon balls.

The Rev. W. Thorp then made some remarks on the boring of Artesian wells, in which Mr. W. S. Ward joined, observing that the system was admirable as regarded boreholes which were dry, but that when there was water in the bore, as was generally the case in this district, little advantage could be expected from the introduction of Fauvelle's method, or of the Chinese or percussive system.

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R. Solly, Esq., then proceeded to read the following Paper on a subject to which his attention had been directed while in South America, namely,—

ON THE TRANSMISSION OF EARTHQUAKE SHOCKS BENEATH GREAT MOUNTAIN RANGES. BY RICHARD SOLLY, ESQ., VICE-PRESIDENT OF THE SHEFFIELD LITERARY AND PHILOSOPHICAL SOCIETY.

No class of phenomena can possess greater interest than Earthquakes to the Geologist, or, indeed, I may say, to any inhabitant of this globe, if modern philosophers are correct in supposing them to be the manifestations of that force by which various portions of the earth's crust are alternately and successively raised above the level of the ocean, and again depressed beneath its waters; changes by which it has been by degrees rendered suitable for the habitation of man. "To these convulsions," says Mr. Lyell, "the present fertility of some districts, the sterile character of others, the elevation of land above the sea, the climate, and various peculiarities, may be distinctly referred." Any contribution, therefore, however trifling, to our knowledge of these phenomena, cannot be wholly devoid of interest, which consideration has encouraged me to read the following observations before this Society.

The great Valparaiso Earthquake of the 19th November, 1822, was felt along the coast of the Pacific as far as Lima to the North, and as Concepcion to the South, a distance of about 1,400 miles; and to the East beyond the Andes as far as Mendoza and St. Juan, a distance of from 300 to 400 miles. The coast was raised in some parts from three to four feet above its previous level for many miles consecutively, exposing rocks covered with shell fish, whose putrefaction infected the atmosphere. Mr. Miers says that "the governor's

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house at Valparaiso, the two castles, and the churches, were all shivered to pieces. * * * No bombardment could have produced such complete ruin as the earthquake effected." Mrs. Maria Graham states that the granite rocks on the promontory of Quintero were rent by sharp clefts, some of the larger of which were a mile and a half in length. I passed some months at Valparaiso in the year 1828, six years therefore after the earthquake, and heard these particulars confirmed by many eye-witnesses. That same year I crossed the Andes to Mendoza by the Aconcagua and Uspallata pass, and I was greatly surprised at the position of an immense mass of rock called the "Peñon rajado," or "Piedra partida," the split stone, situated about half way between the Cumbre and the plain of Uspallata, and 7,300 feet above the level of the sea. It had evidently fallen at some former period from the cliffs above, and had split into two large pieces and several smaller fragments, as may be seen by a sketch which I made on the spot. The equilibrium of both of the larger fragments appeared so precarious, that notwithstanding the extreme heat of the sun's noon rays, one of my travelling companions was afraid to repose under their shade, convinced, as he said, "that the slightest shock of an earthquake would overthrow the enormous mass, and crush us to atoms." Nevertheless our capitaz, or head muleteer, Pedro Aransivia, assured us that these nicely-balanced rocks had not changed their position in his time, nor in that of his father before him; and that they were associated with some traditions of the ancient Incas. I concluded from this circumstance that the great Valparaiso Earthquake had reached Mendoza and St. Juan, a hundred miles further, by passing *under* the great mass of the Andes. A strong confirmation of this opinion was afforded by an intimate friend of mine, who happened to be in the midst of these same mountains during the great Concepcion Earthquake of the 20th Feb-

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ruary, 1835, but who assured me that he was not aware of there having been any earthquake until his arrival at Mendoza, where it had been felt, and he then heard of it. Nevertheless this earthquake was one of the most violent upon record. Mr. Darwin, who was with the *Beagle* on the coast of Concepcion at that time, says, "the effect of the vibration on the hard primary slate which composes the foundation of the island (of Quiriquina, Concepcion Bay) was still more curious: the superficial parts of some narrow ridges were as completely shivered as if they had been blasted by gunpowder."

The above-mentioned circumstances, together with having myself personally experienced several severe earthquakes, naturally attracted my attention to the subject, and I have for some years been in the habit of reading whatever related thereunto, whether in works on Geology or in newspapers; and two years since, while preparing two papers for the Sheffield Literary and Philosophical Society, I carefully examined every book to which I could obtain access on earthquakes and volcanoes, but, with the exception of Baron Humboldt, I was not able to discover that any Geologist had noticed the singular fact of earthquakes having been felt at considerable distances, while *portions of intermediate ground remained unaffected.* That illustrious traveller mentions the above fact in his Personal Narrative; and in his Cosmos (Translation 28th June, 1845, by J. P. T., pages 221 and 222) are the following expressions:—"Could we have daily news of the state of the whole of the earth's surface, we should, in all probability, become convinced that some point or other of this surface is ceaselessly shaken; that there is uninterrupted reaction of the interior upon the exterior going on." * * "It is not the chemical nature of the constituents, but the mechanical structure of the mineral species, that modifies the propagation of the motion, the wave of succus-

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sion. Where the wave proceeds regularly along a coast, or by the foot and in the direction of a mountain chain, it is occasionally observed that there is an interruption suffered at certain points. This has been noticed for centuries. The undulation advances along the depths, but at the points in question it is never felt at the surface. The Peruvians say of these unshaken superior strata 'that they form a bridge.'" In the note No. 159 to the same work it is said,—"With this phenomenon of non-transmission through superior strata is connected the remarkable fact, that in the beginning of the present century shocks of an earthquake were felt in the deep silver mines of Marienberg, in the Saxon Erzgebirge, which were not perceived at all on the surface. The miners rushed up in alarm. Contrariwise, the people at work in the mines of Falun and Persberg felt nothing of the smart shocks (November, 1823,) which threw all the inhabitants above ground into a state of great alarm."

The celebrated traveller whom I have just quoted thus bears unequivocal testimony to the fact that earthquakes sometimes leave portions of ground unaffected in their course; but he states that "the mechanical structure of the mineral species modifies the propagation of the motion, the wave of succussion." This assertion may probably be correct, but it affords no explanation of the fact that similar (and the same) formations of country and like rocks are, at different times, affected by earthquakes in the most dissimilar manner. Vast mountain ranges, composed of igneous and primitive rocks, sometimes appear to escape all effects from the wave of motion; at other times the same mountains are shaken and shattered to such an extent as to change the whole face of the country. Many recent well-authenticated instances of this have occurred,—as that related by the late Sir Alexander Burnes, at Lahore, in February, 1832, when several valleys were choked up by the masses of rock thrown down. The shock of the 20th June, 1840, in the district of

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Mount Ararat, affected equally the summits of mountains and the bottoms of valleys. I myself have witnessed extreme dislocations during earthquakes in the more northern Peruvian portions of the same chain of South American mountains, the Cordillera of the Andes, to which I have already referred as unaffected in 1822 and 1835 by the most violent littoral shocks, dislocations by which the loftiest peaks have been overthrown, and the whole outline of the mountains altered.

It seems to me, therefore, impossible to maintain that the propagation of the motion is regulated by or dependent on "the mechanical structure of the mineral species," although it may sometimes be *modified* thereby.

The conviction which has forced itself on my mind by the examination of all the evidence which I have been able to collect on this subject is, that the motion of earthquakes is transmitted in two ways, generally more or less simultaneous, but different in their effects, namely, by the undulations of subterraneous liquids or fluids, and by the vibration of the earth's superficial crust.

Mr. David Milne has excellently pointed out that most of the English and Scotch earthquakes, being confined to mere patches of the earth's surface, must be due to the latter; and, on the other hand, Professor Phillips remarks that rocks, being very imperfectly elastic, owing to the numerous divisions which intersect them, cannot be supposed capable of transmitting vibration to any very considerable distance. To the subterranean undulations we might, then, attribute the extent of very extensive earthquakes, such as that of Lisbon on the 1st November, 1755, which has been calculated to have shaken near one-twelfth of the whole surface of the globe; also the motion which, passing under without shaking the Andes, has extended from the shores of the Pacific to Mendoza and St. Juan. If the interior of the globe be an intensely heated liquid or fluid substance, we can readily

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imagine that a subterraneous undulation might pass under an enormous mass of mountains such as the Chilian Andes (from 11,000 to 23,000 feet high), which would ride unshaken, while lower ground on both sides suffered; just as we see a ship of the line floating apparently motionless amidst the waves which agitate the little boats at its side.

To the superficial vibration may be attributed the fall of the mountain peaks in Asia and in Peru, the shivered rocks at Quintero and Quiriquina, and those strange rotary motions referred to by Mrs. Graham, by Capt. Fitzroy, and by Mr. Darwin, and of which I have seen remarkable instances at Tacna in Peru, and at Lima. In the latter case, the upper stone of a lofty obelisk was turned half round in 1828, in a manner precisely similar to that in Calabria, of which Mr. Lyell has given a drawing in his Principles of Geology.

The great extent of land and ocean throughout which volcanic and subterraneous agencies have been simultaneously manifested, has compelled all philosophers who have witnessed them to admit the existence at least of vast lakes of melted rock and lava under ground, extending to some hundred thousand of square miles. Baron Humboldt is of this opinion, from the observations he made in North and South America; and Mr. Darwin, who experienced the great Concepcion Earthquake of 1835, makes the following remarks in his journal,—"From several considerations which I have not space here to enter on, and especially from the number of intermediate points whence liquified matter was ejected, we can scarcely avoid the conclusion, however fearful it may be, that a vast lake of melted matter, of an area nearly doubling in extent that of the Black Sea, is spread out beneath a mere crust of solid land."

The astonishing distances at which earthquakes have been felt from the focus of greatest intensity are difficult of explanation on any other supposition than that of internal fluidity; but this is a question which involves so great a

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variety of considerations, that I must not trespass now on the time of this meeting by further remarks on the subject.

The question has frequently occurred to me whether the vibrations, repeated during a long series of ages, which (according to Mr. Darwin) may be supposed to accompany the elevation of a mountain chain, may not have produced considerable changes, all tending to crystalline forms in the molecular constitution of some of the basaltic and metamorphic rocks. It is now an admitted fact that malleable iron, and other metals in a fibrous state, assume the crystalline under the influence of vibration, and without the agency of heat. My friend, Mr. William Lucas, has made valuable experiments on these changes in metals; and I could also have wished to offer a few remarks on two very interesting papers by Mr. Robert Mallet, in the 3rd vol. of the Journal of the Geological Society of Dublin, Part I., No. 2, and Part III., No. 2, but I fear that my present paper is already too long. I shall, therefore, only add how entirely I concur in the valuable suggestion of Mr. Mallet,—"that all the Observatories in connection with the magnetic survey should, in addition to their magnetic observations, record observations as to the occurrence of earthquake shocks."

James Yates, Esq., F.R.S., remarked on the interesting character of Mr. Solly's paper, and particularly the fact which he had stated of the raising of the coast of Lima by an earthquake some years ago; a fact which was recorded by Mrs. Maria Graham, and had been greatly disputed.

Earl Fitzwilliam in a few remarks corroborated the observations of Mr. Yates, as to the value as well as interesting nature of the paper just read.

It was then arranged that the remaining business should be adjourned to the Evening Meeting, and after a vote of thanks to Earl Fitzwilliam, moved by Dr. Scoresby and seconded by Mr. Yates, the Meeting adjourned.

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The Evening Meeting was held in the same place. In the absence of the Noble President, WILLIAM WEST, Esq., F.R.S., V.P., was, on the motion of the Rev. W. Thorp, unanimously called to the Chair.

The CHAIRMAN, in opening the business said, for the kindness—the undeserved kindness—of the Geological and Polytechnic Society of the West Riding of Yorkshire, in having placed him a few years ago on the list of officers, as one of their Vice-Presidents, he felt it his duty, when called upon, to avoid making any demur to the proposition of the Secretary. The first paper to be proceeded with was one by James Haywood, Esq.; but, owing to indisposition, he was unable to attend. The paper, however, had been committed to Mr. Lucas for the purpose of being presented to the Meeting.

Mr. LUCAS said he regretted the absence of the Author of the paper, inasmuch as the Meeting would be deprived of that part which he would undoubtedly have taken in the discussion which would follow. As regarded himself, he was somewhat ignorant of the subject, and could not, therefore, afford them any further edification than what they would derive from the reading of the paper. He then proceeded to read the following:—

ON THE CLOVER SICKNESS OF CERTAIN SOILS: BEING AN ANALYTICAL INVESTIGATION INTO THE CAUSES PRODUCING THE FAILURE OF THE RED CLOVER CROP, WITH SUGGESTIONS FOR ITS PREVENTION. BY JAMES HAYWOOD, ESQ., SHEFFIELD.

Agreeably to the request of the members of the Blyth Farmers' Club, at a meeting held on the 5th of June last, I undertook certain experiments and investigations on the soils furnished to me by Mr. Beavor, of Barnby Moor, with reference to the cause of the failure of the red clover crop. I submitted these soils to a minute chemical analysis, so as to

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ascertain *accurately* the constituents of each. I exposed them to the action of the atmosphere, to ascertain the amount of disintegration; and with a careful analysis of the red clover plant itself, I trust I am now in a position to point out to you the true cause of this hitherto mysterious failure.

You are fully aware that all plants are composed of elementary substances arranged in various ways, so as to form their leaves, stems, and juices,—what these elements are, and how much is contained in a given weight of produce, we can easily ascertain by chemical analysis; and as we know positively that plants have not the power of creating one of these elements themselves, they must be derived from the media in which they live, namely, the air and the soil. This air and soil, then, must contain all the constituents we find in plants, in such a form as they can easily absorb them by their roots, otherwise they can never come to perfection; for observation and experiment have taught us, that the absence of any one of the constituents of plants precludes the possibility of their so doing.

The analysis of a fine healthy red clover plant, dried in the air, and in the ordinary state of clover hay, gave me, in 100.000 parts—

		per cwt.	lbs. per ton. lbs.	oz.	
Derived principally from the air.	Carbon	95.231	2133	3	Volatile constituents. lbs. oz. 2199 3
	Hydrogen ...				
	Oxygen				
	Nitrogen	2.946	66	0	
Derived entirely from the soil.	Phosphorus	.159	3	9	Fixed ingredients or ashes. lbs. oz. 40 12
	Sulphur	.107	2	5	
	Lime	.621	14	0	
	Magnesia...	.071	1	9	
	Iron & Manganese	.002		1	
	Potash...	.580	13	0	
	Soda	.201	4	8	
	Chlorine	.082	1	13	
	Silica	Trace.			
		100.000	2239	15	

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The volatile elements derived from the air are of such little importance in this investigation, that I have not thought it necessary to separate them, as they are well known to be contained in the air in sufficient quantity to meet all present demands; the fixed ingredients, however, have been minutely ascertained by a new process, which insures some degree of accuracy. Instead of burning the substance, as is usually done, I had recourse to nitric acid as an oxidizing agent, and by this means discovered *much more* sulphur and phosphorous than this plant is usually stated to contain; this sulphur and phosphorous exists in combination with the nutritive compounds of plants, and its quantity can never be ascertained by burning. It will be seen that one ton of dry clover contains 3 lbs. 9 oz. of phosphorous, which is equal to 8 lbs. of phosphoric acid, or about 16 lbs. of phosphate of lime, and, as each acre will generally produce about two tons, 32 lbs. of phosphate of lime would be extracted from the soil by each acre of clover. Now it will be seen from the analysis of the soils, both where the clover failed and where it came to perfection, that a much larger quantity of phosphates are contained in them than this crop requires,—hence, if these phosphates can be rendered soluble, the failure of the red clover crop cannot be owing to an imperfect supply of them. Now it is a well-known fact that phosphate of lime is readily dissolved by water containing carbonic acid gas, providing it is minutely divided; now the phosphates existing here are in this state, and, consequently, can readily be dissolved by the rain water, and absorbed by the roots of plants; moreover the soil where the clover *failed* contains *quite as much* phosphate as that where it came to perfection, and, as both were placed under similar circumstances, we may safely conclude that the phosphates have nothing to do with the failure of the red clover crop.

The next element, sulphur, has always been, since the time

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of Sir H. Davy, the one on which all the praise or blame has been bestowed for the success or failure of the red clover crop. This eminent chemist found considerable quantities of gypsum (a compound of sulphur) in the ashes of this plant, and very justly concluded that it would be a valuable compound to add to the soil producing it. At that time, however, so little was known of the origin of the elementary constituents of plants, that a creative power was usually assigned to them, and the fact of their elements being derived from the soil was not at all understood. So great, however, became the rage for the use of gypsum, and *valuable* the effects produced from it in some instances, that it was soon lauded through the country as an universal specific. This, however, like the lightning cultivation, was soon found to be an illusion; and it turned out that in *some instances only* it was beneficial, while in *others it failed.* The true use of gypsum is that of furnishing sulphur to plants, and in preventing the ammonia, which is generated in the soil, or which is brought down by the rains, again escaping into the air by evaporation. If the soil contains a sufficient quantity of this gypsum, both these will be accomplished without any further addition,—it would of course be useless to add more. If, on the contrary, there should be a deficiency, we should lose considerable quantities of ammonia, a large quantity of which the clover plant requires, and we should not supply it with a necessary quantity of sulphur. In this case gypsum would be of service, and, providing all the other elements were duly supplied, might entirely prevent the failure of the crop. It will be seen that one ton of clover contains 2 lbs. 5 oz. of sulphur, which is contained in about 12 lbs. of gypsum; 2 tons, therefore, growing on an acre, would require only 24 lbs. of raw gypsum, a quantity which all ordinary soils contain. It is true the soils subjected to analysis contain unequal quantities of gypsum; the one where the clover plant

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failed contains only half the quantity we find in the other; this small quantity, however, amounts to more than 56 lbs. per acre, which is more than double the amount required for a crop of clover. The reason we always find so small a quantity in the surface soil arises from its solubility in water; portions are carried down by every shower, and fresh portions are brought up, dissolved in water, from below, by capillary attraction during summer; this quantity, therefore, would be considerably increased in dry weather, and would at all times, except in very wet seasons, be amply sufficient to supply plants with the requisite amount of sulphur. There are other facts, also, of a much more conclusive character, which prove beyond doubt the fallacy of the statement that a deficiency of gypsum is the cause of the failure of the red clover crop. There are other plants which flourish on the same land, and at the same time that red clover *dies*, and which contain *considerably more* sulphur than it. I would instance Italian rye grass, which analysis shows to contain .320 of sulphur, which is equal to about 7 lbs. of sulphur, or 38 lbs. of gypsum, per ton; now this is not a plant which dies away as red clover does, but flourishes at the very time: the wild mustard, or ketlock, too, containing nearly double this quantity of sulphur, grows luxuriantly on most soils where red clover fails. Even *white clover* contains more sulphur than *red*, and is not liable to die away; we may consequently conclude, contrary to the old opinion, that the failure of the crop is not owing to a deficiency of gypsum, for if such was the case, plants requiring most gypsum would certainly die first.

Lime and magnesia appear to answer similar purposes in the organism of plants, and may probably replace each other in combination. We find considerable quantities of these earths in the ashes of red clover, particularly the former, which, during the burning, is converted into a sulphate and phosphate. This lime may either be taken up as a sulphate

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or phosphate, as named above, or as a carbonate, and as this carbonate is found in abundance in all fertile soils, no one could ascribe the failure of the red clover crop to this. Experience, however, tells us that the application of lime has an important influence on the growth and development of the clover plant, whether it be red or white, and this on soils where analysis shows the presence of considerable quantities of carbonate of lime; the lime, then, when applied in a caustic state, must exert some chemical action on the constituents of the soil, and thereby act beneficially to the plant, for it would shortly become a carbonate when mixed with the soil, and consequently only increase the quantity of an ingredient which is already present in abundance. The soils I have submitted to analysis contain more than two tons of carbonate of lime per acre, a great part of which has been added to them artificially in the shape of Derbyshire lime; this would probably be a means of preventing the failure of the clover crop when first applied, for reasons I shall presently assign. Magnesia is contained here in such minute portions, that it is next to impossible to detect it by analysis; and although it would probably have little influence on the failure or success of the clover, yet its absence would undoubtedly be a source of injury to such plants as require it in abundance. The deficiency of magnesia cannot be the cause of failure in this case, as the soil where the clover was perfected contained no more than that where it failed.

Iron and manganese are contained in such minute proportions in this and other plants, that they may be looked upon rather as accidental than as necessary constituents. I shall not, consequently, take any account of them in this essay; we shall, however, next come to a substance which, of all others, is the most important of the fixed constituents of plants, namely, potash.

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This potash may be considered as one of the most extensively diffused compounds in nature; it is found in all rocks and soils where a patch of vegetable life can exist—it is a substance found abundantly in the juices of all plants, where it exists in combination with vegetable acids, and undoubtedly plays an important part in the formation of wood and vegetable productions in general. This potash is converted principally into a carbonate when vegetables are burnt, which carbonate remains in the ashes mixed with the other fixed constituents;—it is, in fact, from the wood ashes of America and Russia that our large demand for potash is supplied. Like most other of the fixed constituents of plants, this potash was originally supposed to be peculiar to the vegetable race, and was hence called the vegetable alkali;—it was, in fact, supposed to be an element of their own creation, and chemical analysis had failed to detect its presence in soils. This failure arose from the minute portions of potash which exist in soils in a *soluble state*, and the impossibility of rendering that soluble which existed in considerable quantity, by the means then at command. This potash exists in all rocks and soils in combination with silica, as an insoluble glass which requires the prolonged action of carbonic acid, rains, and other natural agencies to render a small portion of it soluble; it is also decomposed and rendered soluble by the action of alkalies, such as lime, ammonia, &c., an instance of the latter being often seen on the glass of stable windows. Now you are fully aware that all substances which plants extract from the soil must be dissolved in water before they can be absorbed by their roots, hence this potash must become soluble before it can be of the slightest service to their growth. The time required to convert a given weight of this potash into a soluble state, will depend entirely on the quantity existing in the soil, and the presence of the above agents to effect its decomposition—a soil containing four tons of pot-

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ash, combined with silica, per acre, would give off double the quantity of soluble potash in a given time to one containing only two, providing the amount of carbonic acid, lime, or other means of decomposition, were the *same*. And, again, unequal quantities of potash would be rendered soluble in soils where the proportions of silicates were the *same*, providing the means of decomposition *differed:* we might, for instance, in a soil like the one analysed, render double the quantity soluble in one part than another, by supplying it with an excess of carbonic acid or lime. The only means we have of supplying an excess of carbonic acid is by the application of organic matters in the form of manure; the decay of such matters gives rise to an abundance of this gas. Now we find from the analysis that the soil where the red clover died contains considerably less organic matter than the one where it came to perfection; hence I thought it possible that much less potash would be rendered soluble *here* than in the latter case, and I took the following steps to ascertain if such were the fact; both soils and subsoil were exposed to the atmosphere in fine sieves on dishes for three weeks, during which period rain fell frequently, but no liquid was allowed to escape from them; they were then dried in the air, and the amount of soluble matters which they contained carefully ascertained by analysis. The soil where the clover came to perfection gave .1257 of soluble matters, .0024 of which was potash; and the soil where it failed gave only .0372, of which only .0008 parts were potash. Here, then, is an evident difference in the amount of disintegration, to an extent of *one* to *three;* and surely this would produce some effect on a plant which, like the red clover, requires a great quantity of potash for its support. I would not entirely attribute this difference of disintegration to the aid of organic matter present; the *size of the particles containing the potash* would have an important effect in *increasing* or retarding its effects;

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this has been observed by the Rev. W. Thorp, of Womersley, who attributed the failure of the crop to the lightness of the soil. He found a cubic foot of soil, taken from places where the clover failed, always weighed *less* than one taken from places where it came to maturity. Now I imagine this difference in weight would be owing to the quantity of finely divided matter which existed between the coarse particles; hence we are at once able to attribute the cause of the failure, not simply to the mechanical effect of lightness, but to the small quantity of potash which is rendered soluble in consequence of the size of the particles. If this be the true cause of the failure, we can then understand why a chemical analysis shows the same quantity of potash in soil where clover fails as where it succeeds, for without a *mechanical* analysis, without showing the quantity of those minutely divided matters which are most capable of disintegration, it would be entirely useless. With a view, therefore, to set this matter at rest, I had recourse to the simple method of mechanical analysis recommended by the late Mr. Ram. I separated the fine particles from the coarse sand by agitation with water. In the soil where the clover came to perfection we had coarse sand, 78.6; fine ditto, 21.4. The soil where the plant died away, coarse sand, 81.5; fine ditto, 18.5; in this case, therefore, we have a quantity of fine sand sufficient to make an appreciable difference on the amount of disintegration in favour of the succeeding piece, and this, with the additional means of effecting its decomposition, will certainly account for the increase of soluble potash.

Now let us inquire what quantity of potash is required for the development of the clover crop. The analysis shows that 10,000 parts, dried in the air, contain 58 parts of potash; hence two tons, the produce of one acre, would require about 26 lbs.; now the analysis of the portion where the plant failed contained less than this, although it had been subjected to

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disintegration, under the most favourable circumstances, for three weeks. No doubt, at the time the clover died away, not the slightest portion of soluble potash could have been detected, for, be it remembered, that during the heavy rains of winter and spring, considerable quantities of soluble matters, potash, &c., are washed down beyond the reach of the roots of plants, and this, together with the portion extracted by the plant itself, leaves nothing to supply its future demands; nor is the quantity separated by disintegration in this soil sufficient to do so; for, considering the state of the ground during the growth of clover, I should certainly say that not more than 2 lbs. of potash would be liberated per week; consequently, only 20 lbs. would be liberated during ten weeks the clover plant was growing; hence there would be a deficiency of at least 6 lbs. for the crop.

With these facts and considerations before me, I think I am justified in concluding that the failure of the red clover crop (particularly its disappearance during winter and spring) is mainly owing to a want of soluble potash in the soil. I am particularly borne out in these conclusions, by the fact of all causes which tend to liberate potash from its combination with silica, having the effect of preventing its death; and also by the entire success of the red clover plant in soils where potash abounds. You all observe the success of a wheat crop after a good crop of clover, now this proves that much silica and potash has been liberated during its growth, because the remaining portion of the former which the clover does not require at all, contributes mainly to the success of the wheat. The effect of lime, too, in preventing the failure of clover, has often been observed, and this is undoubtedly owing to the well-known effect of lime rendering soluble the potash of soils.

With regard to such crops as turnips, which require more potash than clover, it must be borne in mind that the soil is in

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a very different state: large quantities of manure are usually applied, which contains much potash, and the soil is constantly stirred so as to facilitate the decay of vegetable matter, and promote disintegration of the silicates. We should undoubtedly have much more potash liberated in this case, than we have when the land remains at rest, as it does during the growth of clover; at this time also, be it remembered, evaporation from the surface goes on very rapidly, fresh portions of soluble potash can be brought from below, and none wastes down by drainage.

With regard to the other alkali, soda, the same remarks may be applied as to potash; it exists in combination with silica, and is separate in a soluble state by the action of carbonic acid and general atmospheric agencies;—when so separated, it is absorbed by the roots of plants, and applied to various purposes in their organisms. It is a question whether soda may not replace potash in many of its combinations in plants; indeed analysis proves such to be the case, for we are constantly finding these two substances, (which are exceedingly similar in all their properties,) differing in their proportions to each other in the same variety of plant; in clover, for instance, grown on soils containing much soda and less potash, we find the ashes of the clover contain less potash and more soda than the analysis here given; while in soils containing much potash and little soda, the alkali consists entirely of potash, which indeed appears to be its most natural base. The presence of either of these bases, consequently, in a free state, as far as theory goes, might be considered sufficient to insure a crop when all the other materials are present. There is, however, another compound of soda present in all soils, which is important to the growth of plants,—it is common salt; this does not only supply them with a certain amount of soda, but at the same time gives them their necessary quantity of chlorine, another element

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important to their growth. This common salt is found in all soils to a certain extent, and generally in quantity sufficient to supply their wants; in both these soils, for instance, we find much more common salt than the clover crop required, hence this would have no effect in causing its failure in one case and success in the other. In consequence, however, of the soluble nature of common salt, it is apt to be washed away by drainage; it is therefore advisable to add some in the form of tillage, when such has been the case. Rain water, too, always contains an appreciable amount of common salt, so that we have, to a certain extent, an everlasting supply of it to plants. It is, however, a question whether the quantity supplied by rain is at all equivalent to the amount extracted by some kinds of produce. Indeed, the fact of common salt being found beneficial to the growth of plants, is a sufficient proof that it is not.

Silica, the substance existing in combination with the potash and soda of soils, and of which I have found a mere trace present in the ashes of clover, need scarcely be mentioned with reference to this case; it is liberated in a soluble state along with the potash, and is consequently left in the soil, and continues to accumulate during the whole time the clover plant is growing. It is this soluble silica which is so conducive to the growth of the future crop of wheat. But like all other soluble matters, this silica would in a great measure be removed by drainage during the winter, were it not *stored up* in the *roots* of the clover, and preserved until required. It is a remarkable fact that these roots contain considerable quantities of silica, while the plant itself contains none. The average of several analyses, conducted with great care, gives me five parts of silica in every thousand of dried roots; hence, in the decay of these roots in summer, the silica will be liberated for the use of the wheat.

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I cannot conclude these observations on the elementary constituents of red clover, without a remark on the large quantity of nitrogen it is always found to contain; this nitrogen is the principal constituent of the nutritive matters of plants, and consequently proves the highly nutritive qualities of the clover. It must, however, be borne in mind that this larger amount of nutriment requires for its production considerable quantities of ammonia, or some substance that will yield it by decay in the soil; the ammonia simply supplied by rain water, or absorbed from the atmosphere by the leaves of plants, can scarcely be sufficient to furnish a quantity which is double in amount to that contained in a crop of wheat; hence it is possible that a crop might fail, or be only imperfect, from a deficient supply of ammonia. This, however, would not be the case in the soils now under notice, because they have been supplied with manures to an equal extent. Nor do I think the failure on the sands generally is owing to this cause, or any other than the one just described, namely, a deficiency of soluble potash, arising from the slow decomposition of a mineral which is here found in small quantity.

Having now taken each element separately, and shown from the analysis of the soils the only possible means of accounting for the disappearance of the red clover, during the winter and early part of spring, it will of course be my duty, in the next place, to point out such remedies as I think calculated to prevent it. Before doing so, however, I must observe, that it is possible there may be other causes producing the death of the clover plant, besides the simple deficiency of its constituents. It is only a few weeks ago I had the opportunity of observing, in a field belonging to J. C. Althorpe, Esq., of Dinnington, the gradual disappearance of the red clover from *disease* at the root; of what gave rise to this disease I am unable to form an opinion. It had

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all the appearance of dry rot; the root when cut had irregular brown markings, similar to those presented by diseased potatoes; it had all the appearance of being produced from fungi, which extend themselves in circles, like the fairy rings of grass fields, but not so regular. The patches were in various parts of the field, and all the plants round the edges of these patches were affected; all in the interior, without exception, were dead. I could not, in such a case, state that the disease and disappearance of the clover was owing to a deficiency of potash; on the contrary, I believe such was not the case. Had it been so, other plants would have been found in a dying state where these patches did not exist; but such was not the case. Hence, any suggestions I may make with regard to the preservation of the red clover crop applies only to cases similar to those I have been requested to investigate, and which I imagine are the ones from which the farmer is known to suffer most.

I have before stated my conviction that the failure of the clover is owing entirely to a deficiency of soluble potash in the soil at the time the plant requires this material in abundance. I have shown that the small quantity of potash remaining after the growth of the barley or wheat would all be exhausted by the growth of the clover in autumn, or washed away by the rains of winter and spring; and that, from the small quantity of minerals liberating potash, much less would be rendered soluble in a natural way than was necessary for its growth. It is, consequently, evident that, in order to cause the crop to come to maturity, we must take such steps as will facilitate the decomposition of the potash minerals in the soil, or add something in the form of manure which will furnish potash at the time the clover plant requires it. With regard to the former case, we have two methods of effecting our purpose, namely, by the use of organic manures furnishing carbonic acid, and by the use of lime. In the

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application of organic manures, we seldom have recourse to such as furnish carbonic acid alone; yard manure and other organic matters always yield ammonia, and the general inorganic constituents of plants; nor do we, except at fallow time, mix them sufficiently with the soil to cause them to have much effect on the silicates contained therein. The roots and vegetable fibres, however, which are constantly increasing in all ordinary cultivated soils, yield by their decomposition quantities of carbonic acid, which, acting powerfully on the silicates, has an important influence on the growth of clover and other plants. Under these circumstances, it is advisable to encourage the increase of vegetable matter in your soil, by preserving every particle of waste on your farms, and not allowing so great a loss to take place in farm-yard manure by fermentation before applying it to the soil.

With regard to the use of lime as a means of liberating the potash for the clover, I have no doubt that a portion worked into the land at the time of sowing the barley would produce a beneficial effect. The lime, however, would act with the greatest energy when first applied, consequently a larger quantity of potash would be liberated at that time than at any other; and as this is not the time when the clover plant requires it to any extent, a great quantity would be washed away by the winter rains, and a small quantity only remain for its summer growth; hence this method of liberating potash would not prove so serviceable as we might otherwise expect. This lime might be applied as a top-dressing to the clover in the early part of spring, but its effects would be considerably modified by its not being mixed with the soil, and, I fear, to such an extent as to prevent its being employed in all cases with success. I would certainly recommend, in preference to these methods, that the potash be put on in some artificial compounds, giving

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off potash in a soluble state—slowly and gradually would be the most suitable—for soluble compounds of potash would, in the event of a wet season, be liable to be washed away. Unfortunately, however, we have no such compound of potash at our command, unless it be those which exist in farm-yard manure. We have in this silicates of potash, &c., which, during the decay of the manure in the soil are gradually rendered soluble and become useful to the growth of plants; since, therefore, it has been found possible to grow crops of turnips with artificial tillages, without the necessity of yard manure at all, there will certainly be in all ordinary farms sufficient to manure the clover, and plenty to spare for the wheat crop as well. This yard manure must be put on in the *winter*, or early in the spring; it will then go on decaying and supplying potash during the whole time the clover is growing, and consequently ensure its success. Yard manure from the stable would, undoubtedly, be the best, as it contains and would yield more potash than the generality of others; this arises, you are aware, from its being produced from the clover on which the horses feed, every element of which clover, valuable to the growth of a future crop, is returned to the manure in the liquid and solid excretions. And if it were possible to preserve all the liquid and solid excretions of the animals which consume your clover, by applying them to your next crop in winter and the early part of spring, you might certainly ensure a second, as far as practicable. Then let this principle guide you in the management of this precarious crop, and I have no doubt you will find less difficulty in raising it than you have hitherto done. There are many gentlemen, however, who will believe that they have not manure to spare for this purpose, and think it more profitably applied in other respects; for these we must suggest the use of some salt of potash as a top dressing, and for this purpose the rough sulphates—a product in many chemical works—

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would be the cheapest and best. Half a cwt. of this per acre, mixed with a little common salt and sulphate of ammonia, would be probably attended with success; half of this should be applied in the beginning of January, and the remainder in the beginning of April. We should then have a sufficient quantity of potash in the soil to carry the plant to maturity, as little or none after this time would be lost by drainage.

There is but one other method I can suggest, in concluding this essay, of supplying potash to clover; it is that of exposing the subsoil, which in the sands of Sherwood Forest and most other soils, generally contain more potash than the surface; this, in fact, is always the case where the surface is grey and the subsoil red. In the case now before us there is no less than double the quantity of this valuable matter in the subsoil; if, therefore, this was subjected more extensively to the action of the atmosphere—of lime, or other decomposing agents, which it might be by bringing it to the surface, there would be much less risk of the clover plant dying away than at the present. It is entirely owing to this portion of the soil not being exposed to the atmosphere, or the action of manures, that its potash is not rendered soluble; and it is owing to the surface soil having been so exposed that its potash has diminished in quantity. In every case where vegetable matter of any kind has flourished, and where the decay of the fallen leaves or mosses has gone on for ages, we find the silicate of potash has been entirely decomposed and washed away. In all those patches of dark grey sand which abound in Sherwood Forest, scarcely a trace of this substance can be found; it cannot, consequently, be surprising that these places should be poor and barren, and that red clover can never come to maturity. If these, however, be carefully examined, the dark grain of which they are composed will be seldom found to extend more than ten or twelve inches in depth. Below this we generally find a fine red sand, com-

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paratively rich in potash, and which the present means of subsoiling would enable you to bring to the surface. If this was done I have little doubt that a great deal of the forest land of this character would be reduced from a comparative state of barrenness to one of great fertility. In cases where the subsoiling, from the great depth of the gravel, or from other causes, was found to be impracticable, there are few places where this permanent improvement may not be effected by carting. Sand pits might be made, generally, in the very field where it was required, and a larger quantity applied at a trifling cost. There are even many places where a red clay abounds, much richer in potash than the sand, and which could be carted on in a similar manner. Where sand is used, I have before recommended that you should have some regard to the quantity of that shining mineral, *mica*, which it contains. There are many places where it abounds to such an extent, that each ton of sand contains 37 lbs. of pure potash, a quantity which, if liberated, would be sufficient for an acre of clover; nothing, consequently, could be better calculated to prevent the failure of the clover crop, or confer a more permanent benefit on these soils, than a good application of this. Where such was applied simply with a view to preserve the clover, the potash might be partly converted into a soluble state by previously mixing it with lime. Compost heaps might be made of two parts of this sand and one of lime, ten or twelve months before required; they might then be applied as a top dressing in winter or spring, with, I think, perfect success.

P.S. There is one fact connected with the cultivation of clover which I would beg to offer a few remarks upon previous to concluding. It has been stated to me, on numerous occasions, by the most experienced farmers, that the crop of wheat is always better after *mown* clover than after pastured. They even state that if the clover is mown two or three times,

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the wheat will be better than when mown once: now this, at first sight, certainly appears contrary to all theory, for the food consumed on the soil during pasturing would again be restored to the soil in the liquid and solid excretions; none of the elements useful to the growth of plants would be lost, while in *mowing* the clover the whole of these elements are removed; hence we should certainly expect a larger crop where the elements had been left; but such is not the fact. Admitting that all these elements, which are secreted by the cattle, be washed away by winter drainage, which will probably be the case, we have not even then an explanation of this curious fact. Knowing there must be some cause for it, I commenced an examination of the roots of clover in these circumstances, and from many sources I have ascertained that the weight of root in clover pieces *mown twice*, bears a proportion to those in pastures of three to one.

I have also ascertained that the weight of roots contained in an acre of good mown hay is about 3,630 lbs. (calculated dry), while the weight of roots from a portion of the *same field*, which had been pastured, gave only 1,440 lbs.; hence we have at once an explanation of the cause of success in one case and failure in the other; for these roots, during their decay in summer, furnish materials valuable for the growth of wheat—the carbonic acid which they give off acts powerfully on the silicates in the soil and promotes their solution, while the nitrogen which they yield, which in the mown portion amounts to 54 lbs. per acre, furnishes that important element to its growth. These decompositions, of course, will go on with three times the vigour where there is three times the weight of root; hence the cause of this curious phenomenon is no longer a mystery.

I believe I have now taken every subject into consideration with regard to the failure of the red clover crop on the sand lands generally, as well as the probable means of preventing

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it. If the suggestions I have made should, on due trial, prove that I am right, I trust that they will confer a lasting benefit on the agriculture of this district. If, on the contrary, they should not be found to succeed,—like all those who have investigated the subject before me, I must content myself with having made the effort, though unsuccessful.

ANALYSIS OF SANDY SOIL, FROM MR. BEAVOR, BARNBY MOOR, WHERE THE RED CLOVER DIED AWAY.

Specific Gravity, 2.265. Dry Gravity, 1.350. One cubic foot in a dry and porous state weighs about 100 lbs. One acre, six inches deep, about 1000 tons.

		per cent.	Per acre, six inches deep. tons.	cwt	lbs.
Stones and Gravel, consisting of Silica and Silicate of Alumina; little prone to disintegrate, and incapable of furnishing any ingredient serviceable to the growth of plants		16.250	162	10	0
Organic Matter, yielding Carbonic Acid, and all the constituents of plants by decay.	Roots and Fibres in a state of decay	.110	1	2	0
	Organic Matter, principally Humus, containing a trace of Ammonia	1.870	18	14	0
	Water of Absorption	1.955	19	11	0
Coarse and Fine Siliceous Sand, insoluble in Acids; containing Minerals capable of disintegration, and furnishing Silica and Potash to Plants.	Silica	68.000	680	0	0
	Alumina	10.020	100	0	0
	Potash	.200	2	0	0
	Soda	.052	0	10	45
	Lime and Magnesia	.013	0	1	67
Substances Soluble in Acids.	Peroxide of Iron	.769	7	13	89
	Protoxide of Iron	.140	1	8	0
	Oxide of Manganese	.trace			
	Free Alumina	.120	1	4	0
	Carbonate of Lime	.153	1	10	67
	Carbonate of Magnesia	.trace			
	Phosphate of Lime and Iron	.059	0	11	90
Substances rendered Soluble by the action of the Atmosphere, by three weeks' exposure to rain, &c.	Humate of Lime, with a little Ammonia	.0321	0	6	47
	Sulphate of Lime	.0025	0	0	56
	Chloride of Sodium	.0016	0	0	36
	Potash	.0008	0	0	16
		99.7480			
	Loss	.2520			
		100.0000			

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ANALYSIS OF SOIL FROM THE SAME FIELD, WHERE THE CLOVER PLANT CAME TO PERFECTION.

Specific Gravity, 2.265. Dry Gravity, 1.350. One cubic foot in a dry and porous state weighs about 100 lbs. One acre, six inches deep, about 1000 tons.

		per cent.	Per acre, six inches deep. tons. cwt. lbs.
Stones and Gravel, similar to the former, incapable of disintegration, or being serviceable to the growth of Plants		15.500	155 10 0
Organic Matter, yielding all the constituents of plants by decay.	Roots and Fibres in a state of decay	1.070	10 14 0
	Organic Matter, principally Humus	1.812	18 2 45
	Water of Absorption	1.275	12 15 0
Coarse and Fine Siliceous Sand, containing Minerals, capable of disintegration, and furnishing Potash and Silica to Plants.	Silica	68.000	680 0 0
	Alumina	10.270	102 14 0
	Potash	.324	3 4 89
	Soda	.080	0 16 0
	Lime and Magnesia	.040	0 8 0
Substances soluble in acids, the useful parts of which are conveyed to plants by the carbonic acid contained in rain-water.	Peroxide of Iron	.740	7 8 0
	Protoxide of Iron	.040	0 8 0
	Oxide of Manganese	.013	0 2 67
	Free Alumina	.074	0 14 89
	Carbonate of Lime	.212	2 2 44
	Phosphate of Lime and Iron	.062	0 12 44
	Carbonate of Magnesia	.trace	
Substances contained in the soil in a soluble state, and rendered soluble by three weeks' exposure as the former.	Sulphate of Lime	.0059	0 1 20
	Potash	.0024	0 0 54
	Chloride of Sodium	.0040	0 0 89
	Humate of Lime with Ammonia	.1120	1 2 44
	Soluble Silica	.0014	0 0 31
		99.6377	
	Loss	.3623	
		100.0000	

ANALYSIS OF SUBSOIL FROM SAME FIELD.

Specific Gravity, 2.268

Stones and coarse Gravel, similar in composition to that contained in the surface soil		17.000
Roots and Vegetable Fibres		.020
Organic Matter, principally Humus		.320
Water of Absorption		1.314
Coarse and fine Sand, slowly disintegrating by the action of the atmosphere.	Silica	67.500
	Alumina	8.520
	Potash	.452
	Soda	.120
	Lime and Magnesia	.050

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Soluble in Acids.	Peroxide of Iron	2.500
	Protoxide of Iron	.100
	Oxide of Manganese	.240
	Free Alumina	1.420
	Carbonate of Lime	.068
	Carbonate of Magnesia	.094
	Phosphate of Lime and Iron	.028
Soluble in Water after exposure as the former.	Sulphate of Lime	.0045
	Soluble Potash	.0024
	Chloride of Sodium	.0030
	Soluble Silica	.0022
	Humate of Lime	.trace
		99.6931
	Loss	.3069
		100.0000

The Rev. W. THORP intimated that from Barnsley to Ferrybridge, out of 450 acres of clover, about 200 failed; that it usually fell from November to March; and that from observations which he had made by a common microscope, the stalk becomes soft, dark coloured, or brown, like the disease in the potato plant.

After remarks from Mr. WEST, Mr. LUCAS took the chair for the purpose of allowing Mr. WEST to read his Paper:—

ON WATER FOR STEAM ENGINES: ITS CHEMICAL ANALYSIS, AND SOME PROPOSED REMEDIES FOR INCRUSTATIONS IN BOILERS. BY WILLIAM WEST, ESQ., F.R.S., V.P., LEEDS.

When locomotive engines, in consequence of the splendid invention of the tubular boiler, were first extensively applied to railways, it seems as if engineers had been content to rest upon a very obvious truism,—water is water; and, omitting all inquiry as to *quality*, had been satisfied with securing a sufficient *quantity* at each watering station. That this continued to be the case on some lines for several years, I know.

In one of the instances in which I was at a later period employed to analyse and report upon many springs proposed as substitutes for water which had been found very mis-

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chievous, a sum not less than £2,000 had been expended on the construction of a reservoir, and the Directors had then under consideration estimates to a large amount for its alteration, so as to admit new streams and exclude some of the old. In another case, much trouble and expense were incurred in attempts to obtain a supply of improved quality, with very indifferent success, though a river, yielding very good water, was within a quarter of a mile of the terminus. The space between being covered with houses, many of them held by small proprietors, there was no chance of obtaining consent from every owner to the laying down of pipes to the river without a fresh Act of Parliament, though it was currently stated that had the contingency been foreseen, little or no opposition would have been made to the insertion of the needful clauses in the original Act.

In these instances, and in others within my knowledge, the inquiry after better water has been forced upon engineers or proprietors of steam engines, by the destruction of a boiler and its appurtenances, in a period of time far shorter than ought to elapse between the construction of an engine, and its requiring such repair. In others, the quality of the water has been attended to at the beginning, as well as its quantity; and where there has been opportunity for choice, that has been selected which chemical analysis has shown to be best fitted for the purpose. In others, I doubt not, the old hap-hazard routine is continued, of employing indiscriminately such water as can be most abundantly or most cheaply obtained, and changing it if mischief is occasioned to such an extent as to become intolerable. The manner in which this mischief shows itself is by the deposit of an earthy fur or crust upon the tubes principally, but also upon the body or "shell" of the boiler.

This crust consists chiefly of carbonate of lime, sulphate of lime, or a mixture of these two. Such substances con-

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duct heat much more slowly than the metals; when, therefore, the surface, either of a plate or tube of metal, which should be in immediate contact with the water, is so encrusted, the caloric passes slowly through, and accumulates proportionably in the metal, which oxidates with corresponding rapidity on the side exposed to the fire. When this state of things exists to a great degree, the fire which would raise, with a clean boiler, the needful quantity of steam, becomes insufficient, and its increased heat augments the injury to the boiler.

Besides the injury to the different parts of the boiler, an increased consumption of fuel, and even difficulty in obtaining, by any means, a sufficiently rapid generation of steam, are additional reasons for attention to the quality and selection of water. The substances present in common spring or river waters are soda, lime, magnesia, as bases; and sulphuric acid, carbonic acid, and chlorine, which represents hydrochloric or muriatic acid. Iron and organic matter, either animal or vegetable, occur occasionally. Several other substances, as potash, iodine, nitric acid, and others are met with, either in proportions so minute, or with such comparative rarity, that they need not be taken into account on the present occasion.

We may confine our attention, then, to the bases and acids above-mentioned. Respecting the manner in which these are combined or grouped by nature in the water in its original state, chemists are by no means agreed. Carbonate of lime, for instance, as such, is insoluble in water alone; yet it is separated from it frequently and abundantly, carbonic acid being in most cases disengaged at the same time. Now, one chemist believes that in these cases the lime is in the state of a true bi-carbonate, and reports it to contain that substance. Another chemist denies the existence of such a salt as bi-carbonate of lime; for he considers the excess of

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carbonic acid as a mere solvent, and reports neutral, or common carbonate of lime. Again, if sulphuric and carbonic acids, soda, and lime, are present in small proportions, chemically equivalent to each other, it is possible that one chemist may report the presence of

Sulphate of soda .....(40 and 32)....	72
Carbonate of lime .....(22 and 28).....	50
Total	122

Another might state the composition to be—

Carbonate of soda..... (22 and 32).....	54
Sulphate of lime	68
Total	122

Their totals agree, their acids and bases are the same. These are matters of direct experiment, in which ordinary correctness will secure uniformity; but from difference in their opinions as to the grouping of the acids and bases, the salts mentioned are quite different: neither of those which composed the total in each is mentioned in the other. The determination of that point, the furnishing a decisive victory to either class of opinions, is not by any means at present within our reach, or, to all appearance, likely ever to be so within the range of direct experiment: the question is one of inference and probabilities. The practical consequence of this disagreement is, that, as in the above instance, salts may be stated to be present in one report, which are wholly absent from the other. If such salts are present in any other than chemical equivalent proportions, the quantities will be modified: thus we might have

Sulphate of soda	72
Carbonate of lime.....(50 and 20).....	70
Total	142

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Or,

Carbonate of soda	54
Sulphate of lime	68
Carbonate of lime	20
Total	142

Let not the non-chemical engineer rashly conclude that the members of his kindred profession have no rules for their guidance, that there are no points on which they are agreed; still less, that chemical analysis is an unessential matter, purely theoretical, and definitively settled.

While the controversies between the partisans of locomotive and atmospheric, screw and paddle, broad and narrow gauge, are urged with their present talent on either side, and remain in their present state of indecision and absence of conviction to each other, engineers may look with charity upon those divisions which are not only more speculative than practical, but rather apparent than real. For chemists know immediately what is intended, and, different as to an unpractised eye the two statements may appear, to the chemist it is not the actual composition of the water which differs, *but the language in which the results are stated;* and he translates with facility that *mode of expression* used by another chemist into that which he is accustomed to employ. The reason of this difference in expression is, that when water is concentrated by evaporation, almost to dryness, the acids and bases present, however combined originally, and whether in a natural water, or introduced as salts in any specified order of arrangement, form ultimately those compounds which are *least soluble* in water. Excess of carbonic acid, if present, is at the same time disengaged.

He, therefore, who either states the salts which he has actually so obtained by evaporation, or, having ascertained, by the same methods as others, the quantities of acids and

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bases, groups them as they would separate when evaporated, will report, as in my first example.

But there are strong grounds for believing that under the influence of the water present in very weak solutions, like natural waters, the grouping is the direct reverse of that which takes place when that influence is withdrawn by evaporation. I need not here detail these reasons which are in part drawn from considerations of the medicinal effects of stronger mineral waters: sufficient to observe that there is nothing *à priori* illogical in the view that where water is the agent in imparting fluidity, the state in which the salts subsist, while thus fluid, should be that of those most soluble; that is, having most disposition to assume this kind of fluidity, and these also possessing the greatest affinity for water, so far as solubility in a fluid denotes affinity for it.

The chemist who, whatever his reasons for adopting the hypothesis of "salts of greatest solubility," has adopted and adheres to it, will state his analysis in the second form—carbonate of soda, sulphate of lime, or, in the further instance, carbonate of soda, sulphate of lime, carbonate of lime. I belong to the "greatest solubility" faction, as believing it, though not perhaps invariably applicable, to express generally what actually takes place in nature, and in the numerous analyses in which I am engaged of waters for medicinal purposes, to be also the most useful practically. But in analyses of railway waters, or waters for boilers of any kind, where we have to do with the results of evaporation, and with these only, I consider it my place to say what evaporation will produce, rather than to mislead by attempts at theoretical exactitude. If I speak in one language to physicians, and in another to engineers, each is, however, a faithful expression of, and exactly equivalent to the other.

One circumstance which I believe often strikes those to whom the subject is new, is the smallness of the quantities

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reported in waters, respecting which strong opinions are expressed by chemists. Accustomed to deal with thousands of tons, and having, perhaps, never seen grain weights, or perhaps seen them as the mere spangles used for apportioning doses of the most powerful medicines, the engineer who sees three-quarters of a grain mentioned as present in a pint, may be excused if he is tempted to consider such a fraction not only unimportant, but insignificant. But let this three-quarter grain per pint be deposited from one thousand gallons, without being removed, and it will amount to nearly fourteen ounces avoirdupois,—a very tangible quantity.

The carbonate of lime deposited from natural waters may have been dissolved in either or both of two ways; either as carbonate dissolved by excess of carbonic acid, which is driven off by boiling; or lime present, as sulphate or muriate, if carbonate of soda be also present, will form carbonate by decomposition, when the solution becomes concentrated.

Sulphate of lime may also exist in water, as sulphate, in a larger quantity than will be found at present; or it will be formed of muriate of lime and sulphate of soda, reacting on each other. As soon as the solution is concentrated to such a point that the water present is insufficient to hold the whole dissolved, the excess will be deposited. But much may be separated in the solid form, during the brisk boiling of a solution far from saturated. I described, many years ago, in print, how this takes place. When a bubble of steam arises, the salt of *any description*, which it held dissolved, either is really, or, to render our explanation clearer, may be supposed to be for a moment, left behind in the solid form. If the salt is abundantly and rapidly soluble, like sulphate of soda, it is so instantaneously re-dissolved, that practically the case is as if it never had separated.

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But sulphate of lime, like all difficultly soluble salts, requires an appreciable portion of time for its solution; and before the fragment left by one bubble is dissolved, myriads of others are formed, which even a weak solution cannot take up before they are aggregated into masses which present less surface, and still further resist the solvent action of the water. Hence they may be, and I doubt not are, deposited from a solution briskly evaporated, but considerably below saturation.

Carbonate of magnesia accompanies carbonate of lime in many waters, and is subject to nearly the same laws; it is insoluble in water alone: is soluble by the aid of excess of carbonic acid, and precipitated when this is disengaged by heat. But sulphate of magnesia, being a salt very easily soluble, does not separate in the indirect and curious manner in which sulphate of lime separates from weak solutions.

In many crusts which I have examined, I have found a mixture of these three substances, carbonate of lime forming always the largest part, sometimes almost the whole; carbonate of magnesia is sometimes present, sulphate of lime frequently.

Carbonate of lime, in native crystals, is harder than sulphate of lime; calc spar scratches gypsum, and is not readily scratched by it. In the loosely coherent state in which these salts are at first deposited in a boiler, the true hardness of each minute crystal is no guide to the hardness of the aggregate. And I am decidedly of opinion, from my observations, that sulphate of lime is more disposed to attach itself to foreign bodies, as the plates or tubes, than carbonate; and that a mixture of sulphate gives a closer and firmer texture to the mixed deposits, than is possessed by the carbonate alone. I therefore look with jealousy on all waters containing much sulphate of lime, whether it be accompanied by a large or small proportion of carbonate of lime.

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The empirical rule which I suppose guides such engineers and directors as reject the aid of chemistry, and yet profess to follow some rule, and not to trust entirely to chance in the selection of water, is, I suppose, to prefer such water as is "soft," and to exclude "hard" springs. To a certain extent this is correct, but not without great exceptions. Chloride of calcium (muriate of lime) decomposes soap, and, therefore, for domestic purposes, imparts hardness in such proportion that about 56 parts produce the same effect as 68 of sulphate of lime and 50 of carbonate of lime.

But since muriate of lime (chloride of calcium) is an exceedingly soluble salt, it does not, as such, form any portion of crust on boiling. Water containing nothing besides muriate of lime would not "fur" at all; and in so far as the mixture of earthy salts which interferes with the use of soap consists of muriate of lime (and in practice it sometimes forms a large portion), will the "hardness" to soap, and the disposition to "fur" vary from each other. If we compare by means of soap, or, what is nearly the same thing, by their reputed hardness, a water containing 10 grains of carbonate of lime, with another containing 5 of carbonate of lime, and 15 of muriate of lime, the other ingredients, if any, being in each case the same, the first specimen would seem only half as objectionable as the second, while it is really twice as bad for the boiler. The total solid matter in solution is a yet more vague method of judging, because this will include not only the readily soluble muriate of lime, but the salts of soda, which do not form insoluble crusts at all.

Whether we employ the terms "hard" and "soft" in the popular sense, or restricted to the formation of fur, we have at present no line drawn between the two, and scarcely any approach to naming a standard, those superior to which should be called good, those inferior, bad waters. As exact

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analyses by chemists are multiplied on the one hand, and observations by engineers as to the actual results with waters of known composition on the other, some approximation to such a standard will be arrived at. At present the engineer, when not acquainted with chemistry, probably depends more on the opinion appended by the chemist to his numerical statement, than on that statement itself. It may give a better idea than in any other way, what character I attach to certain numbers, if I copy a few analyses, with the report upon each :—

No. 1 contained

Carbonate of lime.....	24¼	grains per gallon.
Muriate of magnesia	12¾	„
Sulphate of soda	35	„
Total	72	

When such water as the above is evaporated, the carbonate of lime separates, and as the quantity is large, the water is very unfit for the purpose it is applied to.

No. 2, river water :—

Sulphate of lime...	2	grains, nearly.
Muriate of lime	1½	„
Carbonate of lime	5	„
Dissolved vegetable matter	2	„
Total	10⅓	„ or 2⅓ oz. per 100 gallons.

The quantity of suspended earthy and vegetable matter was 9½ grains per gallon when dried. The carbonate of lime actually separated on boiling was 4.8 per gallon, or about 1 oz. per 100 gallons. Hence this water, *if free from mud*, would be very fit for boilers; but taken directly from the river, in its present turbid state, some of the mud will adhere to the metal, producing the same evil as if dissolved. Such muddy water is also liable to the serious defect of "priming." It should, therefore, be rendered clear by subsidence or filtering.

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[Other analyses were given, which we regret our inability to insert.]

That in a large proportion of cases, my reports are substantially unfavourable, though in such guarded language as—"not the worst I have known,"—"better is desirable if it can be procured," is not to be imputed to my being hypercritical; but to the fact before adverted to, that chemical analysis is not often resorted to at the period when it would be most useful, at the formation of the line, when the quality of the water might enter as one element into the fixing on the exact site of a station, but that it is when the water is found unfit, that an analysis is thought of.

In regard to a remedy for crust, I believe the best is to select such water as, from its obvious softness, or from analysis, is shown to be of a good kind. Where no very good water is to be found near the spot which on other accounts must be selected for a railway station, or a steam engine, frequent and early drawing off and "blowing out" will remove much of the separated earthy matter before it has time to attach itself firmly to the boiler.

I have repeatedly heard that potatoes, or other similar substances, are in actual use, in the boilers of some stationary engines; they must act by enveloping the particles of earthy matter in a slimy coating, which lessens the tendency to adhere to each other, or to the metal, not by diminishing the quantity. They could not be applied, I think, in locomotives, without inducing the other defect of priming. One patent enumerates among the methods which it claims, the having some part or parts of the boiler, away from the hottest portion of the furnace, at a lower level than the rest, and so situated that the eddies of the water, in its course from the hotter to the cooler portion and back, should leave much of the deposit in these recesses, where, the inventor imagines, I apprehend correctly, they would adhere less firmly than to the strongly heated plates.

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I have several times been asked whether some acid could not be added to the water which should hold the lime in solution.

No doubt it could, but alas! for this class of projectors, the excess of acid would act ferociously, at the boiling temperature, upon the metals themselves. Dr. Clark, of Aberdeen, has a patent for the use of lime water in such proportions as shall exactly saturate the excess of carbonic acid, and precipitate both the carbonate of lime originally present, and that formed from the lime added. The process is ingenious, and does credit to Dr. Clark's sagacity, but I fear it would not apply to railway waters. It would leave the sulphate of lime; its efficacy in any case depends on the exact adjustment of the lime added to the free carbonic acid in the water; as this varies, so must the lime water to be added; and I fear that engineers would recoil from the apparatus of settling tanks, or of filters, needful for clearing the water from the carbonate of lime, after it had been reduced to the insoluble form. We are therefore thrown back on the selection of the best waters which the neighbourhood of a station may afford; on chemical analysis to assist in that selection; and in those situations where none can be obtained but what is of poor quality, drawing off the residual portion, or what is called, I believe, blowing off frequently; and what is of equal consequence, as early as possible after a journey, or course of journeys, so as not to allow time for adhesion in a firm crust to take place to the utmost.

As my object in the present instance has been to point out to engineers how they may best apply the resources of chemistry, in their own hands, or those of others, to the selection of water, I may add one or two further remarks. Waters collected in districts where the strata are siliceous are generally most pure the nearer they

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are to their source, whether this be a spring or surface drain. I have found in such as little as three grains of solid matter altogether, in the gallon, as they dissolve more than they part with, in their subsequent course. Waters springing from, or collected upon limestone or chalk, deposit considerably from exposure to the air, agitation, and the action of the sides and bottoms of brooks and of reservoirs. The condition of these, therefore, is improved by being conveyed in natural or other open channels, and by absorbing in ponds and reservoirs. Many clays contain no small proportion of sulphate of lime; the composition of such clay as is used for puddling is, therefore, not beneath the notice of the engineer. In selecting cases for analysis, it is desirable either that a time of drought, when the waters commonly are strongest, should be chosen, or at least ordinary average weather. If taken during heavy rains, the results of analysis will represent the water as more diluted, and therefore better than it really is. Lastly, I would recommend that the quantity of water should not be too small.

It is not wise to increase the difficulty of analysis, or to exclude those collateral experiments on the effect of exposure and subsidence, boiling, &c., which may prove as useful as the analysis itself. One or two gallons is a good quantity.

Within a short period, however, I believe a few months, a method has been proposed by Dr. Ritterbandt, for preventing incrustation even from very hard waters. His remedy is muriate of ammonia, crude sal ammoniac (well known to boiler-makers for a different purpose, as one ingredient in a cement for iron); and its use in hard waters is founded on the remarkable fact, that though when muriatic acid, lime, carbonic acid, and ammonia, in equivalent proportions, or at least excluding great excess of carbonate of ammonia,

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are present in the same cold solution, the ammonia takes the muriatic acid, and remains with it in solution, while the lime combines with carbonic acid, and precipitates as carbonate of lime S; yet at the temperature of boiling water, these affinities are reversed. Lime then takes muriatic acid, or, in modern nomenclature, the calcium of lime takes the chlorine of muriatic acid, and chloride of lime, an extremely soluble salt, remains in solution; while ammonia takes carbonic acid, and is driven off as carbonate of ammonia. Thus all precipitation of carbonate of lime is prevented. Dr. Ritterbandt assumes that sulphate of lime, and carbonate of magnesia, the other and minor constituents of some crusts, will not form hard or coherent masses without the presence of carbonate of lime; and without being prepared to confirm this assertion, I should readily admit that if we get rid, by this, or any other method, of carbonate of lime, the others are, from their very quantity, of less importance.

Mr. Gooch, the engineer to the London and South Western Railway Company, states that he has tried the method to some extent in locomotive engines with great success. He likewise states that it has succeeded in preventing incrustation in marine boilers, fed by salt water, and that it is only necessary to draw off the residual concentrated solution of salt once in ten or twelve days, instead of daily. Mr. Gooch states that he has had the water, after the use of muriate of ammonia, tested by a chemist, and that it shows no sign of the presence of any metals which would indicate the action of muriate or carbonate of ammonia, either on the iron boiler or the brass or copper tubes. It would be desirable that this should be further tried, and confirmed. Another of Mr. Gooch's statements is, I doubt not, correct: that when an incrustation has been formed, it is detached, and partially or

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wholly dissolved, under the use of muriate of ammonia. Dr. Ritterbandt's method is protected by patent, and I have here some copies of his prospectus. The method is equally well adapted for stationary and for locomotive engines, and well deserves a trial. I do not consider that it supersedes the need of chemical analysis, since this would be as available as ever in determining beforehand whether a water is likely to fur or not; and where it is found that it will, or where incrustation has already taken place, an analysis of the water will determine the exact quantity of muriate of ammonia needful in each case.

This method appears applicable to domestic boilers, where steam alone is wanted; but I think it is not where the water itself is to be used.

After a few remarks from Mr. W. S. Ward, the meeting broke up.

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE THIRTY-FOURTH MEETING, HELD IN THE MUSIC SALOON, WAKEFIELD,

ON THURSDAY, THE 20TH MARCH, 1847.

The Rev. THEOPHILUS BARNES, A.M., Vice-President, in the Chair.

The CHAIRMAN opened the meeting by an appropriate address, in which he dilated upon the importance and advantages of the Society, as embracing alike the most useful information connected with the Geology and Mining operations of the district, as well as the Polytechnic or Mechanical department, more especially bearing upon the same subjects. After enumerating several of the Papers which had occupied the attention of the Society at the last few meetings, and suggesting one or two subjects which he considered worthy of their consideration, he observed:—I am glad to find that this day we shall have two subjects, at least, brought before us, of vast importance at a period like the present. The one "On the Ventilation of Coal Mines;" which, after the very recent lamentable catastrophe at the Oaks Colliery, near Barnsley, would not fail to arrest the attention of every person who was desirous to save the lives and lessen the dangers of a class of operatives the most useful, and, at the same time, the most exposed to accidents, which, when they occurred, affected not only themselves, but,

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generally, a large number of individuals depending upon them for their daily bread. Many eminent men, from Sir Humphry Davy to the present time, had been endeavouring to alleviate the amount of wretchedness which they were so frequently, he was sorry to say, called upon to deplore, and he felt glad that their worthy Secretary, Mr. Thorp, had also entered the list for effecting so desirable an object. The second Paper to which he alluded was "On the Strength of Materials." Now, when he saw such stupendous undertakings in connection with our various railways, the viaducts, bridges, &c., it often occurred to him how essential it was that the utmost caution should be used in their construction, that they should be upon the soundest principles, and of the materials most likely to resist the constant wear and tear to which they would afterwards have to be subjected by the passing and re-passing of the railway trains. He should now call upon Mr. WARD to read the first Paper.

ON THE STRENGTH OF MATERIALS. BY WILLIAM SYKES WARD, ESQ., LEEDS.

After briefly alluding to various formulæ for the calculation of the strength of beams, and particularly the experiments and formulæ of Mr. Hodgkinson, as published in several of his Essays in the Philosophical Transactions, and Reports of the British Association, and in a more accessible form in the second part of his new edition of Tredgold's Essay on the Strength of Cast Iron, and which were exemplified by numerous diagrams, Mr. Ward observed, I do not find that the strength of wood beams trussed with rods of wrought iron has been investigated by any writer on the Strength of Materials. I have given some consideration to the obtaining a formula for finding the additional strength which the rod of iron gives to the wood beam,

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and, for many cases, I think the following formula may be employed:— $W = \frac{C \times A \times D}{4 L}$, C being the tensile strength of the rod, A its area, and D the depth from the neutral area of the beam, say at $\frac{2}{3}$ of its depth, to the bolt under the beam over which the trussing rod passes, or to which it may be attached. I think this formula will apply when the strength gained by the rod is greater than the original strength of the beam, or when the trussing rod is attached to a pillar much deeper than the beam. In the former of these cases it will also be needful to ascertain if the beam be strong enough, as a pillar, to bear the compression of the rod.

There are cases in which the advantage obtained by trussing a beam with a wrought iron rod would be estimated at very little by the foregoing formula; the advantage is, nevertheless, very decided in practice. For instance, when a very shallow beam is trussed by a rod not extending to a greater depth than that of the beam, the formula would shew very little additional strength. As the case is very different in fir timber and cast iron, as regards the relation between the tensile and compressive strengths, the tensile strength in fir being much greater than the compressive, it would appear of little moment to add to the stronger, for the rod appears to add only to that part of the beam exposed to tension.

The advantage, however, appears to me to arise in that the beam being pressed upwards by the action of the trussing, so as to become somewhat arched upwards, the neutral axis is brought nearer the lower part of the beam, and a greater portion of the area is in a condition to resist the compressive strain; and also the beam, instead of being exposed to the compressive strain mostly along the upper side, receives the compressive strain in a direction nearly coincident with its axis: and we have seen that a pillar will bear three times more strain in the direction of its axis than along one side.

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We may, therefore, conceive that much greater advantage would arise from such trussing than is pointed out by the formula.

There is much analogy between such considerations of trussed beams, and the results of some experiments by M. Duhamel on beams of soft wood, into the upper side of which a cut with a saw having been made, a wedge of hard wood was driven.

But it would be vain to attempt to reduce these vague ideas, or the effects derived from such varying causes, to any formulæ, without much previous investigation of the laws of the stiffness of beams, and many experiments, conducted with the greatest care, and of a very expensive nature, as it would be necessary that they should be on a considerable scale. The necessity of such experiments is now apparent from the frequent use of cast iron girders, trussed with rods of wrought iron. In regard to these, the results of the inquiries consequent on the falling of the Dee Bridge shew that substantial data are wanting, particularly as regards the effects of temperature on such structures as are compounded of cast and wrought iron.

If I may throw out an opinion on this subject, I think that trussing should not be resorted to for the purpose of giving absolute strength in a weak structure, but that the girder being made strong enough, trussing may be advantageously used so as to confer stiffness.

Perhaps the most important part of our subject is the consideration, What is the proportionate load which may be borne with safety, in comparison with the weight which, according to calculation, would break the structure? It would evidently be very unsafe to load a beam or a pillar with a weight just, or nearly, sufficient to break it, for then the slightest additional weight or load incautiously added, the vibration produced by wind, or tremor

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arising from any source, might cause the destruction of the edifice.

Before entering fully into this, it is necessary to consider the effect of impact, that is, of a body or weight falling with the accelerated force due to gravitation. The effect of a falling body impinging upon another, is in the ratio of the weight and the distance fallen through. Thus a weight of 1 lb. falling through three feet of space, would produce the like effect as a weight of 3 lbs. falling through one foot. I have not found any accurate statement of the space through which a body must fall, to double by impact the effect of its dead weight; but I suspect from the results of rough experiments, that such space is only about three quarters of an inch; I find also that in experimenting with any contrivance like a scale beam, there is much less of force from flexure or extension, and much uncertainty arising from vibration. I, however, further find, that a weight of $\frac{3}{4}$ of a lb. falling through thirty inches, on a wire which would support 30 lbs. weight, just snaps off the wire.

It would, therefore, appear that where a structure is exposed to the impact of bodies falling even from slight distances, the load on it must be very light in proportion to the breaking weight, in order to allow for the effect of impact. It has, however, been observed by Mr. Hodgkinson, that a beam or a wire, when moderately loaded, is better able to sustain impact than when without load, up to a certain ratio between the breaking weight, the weight sustained, and the weight of the body impinging; that is, the greatest resistance to impact is when the weight of the load, including that of the impinging body, is equal to one-third of the breaking weight of the beam or wire.

An idea is entertained by some persons, that no material, however strong, is capable of sustaining any weight, how-

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ever small, for ever, but that the material is constantly losing its sustaining power, or is, in fact, breaking by imperceptible degrees. This idea is borne out by experience in cases where the weight sustained is not constant, or does not press always in one direction; thus, a spring is somewhat broken every time it is bent. But such decrease of strength either does not take place in regard to pressures not approaching the breaking weight of the material, and the direction of which is not changed, or so slowly that it need not be considered. In fact, if such element of calculation were admitted, we must make all permanent structures infinitely strong.

Experiments tend to prove, that in taking one-third of the breaking weight as a safe quantity to be borne by beams, is to err on the safe side; and I am inclined to think it would be abundantly sufficient that the breaking weight of a beam, carefully ascertained, be equal to twice the weight which would ever be put upon it; but as vibration produces a very decided effect, such limit ought not to be passed.

The general rule is, to make a beam at least three times as strong as the weight it has to carry. This appears to have arisen from an idea that one-third of the breaking weight was the least weight which would produce a permanent defect of elasticity of a beam that is "a set." Mr. Hodgkinson has, however, shown, that much less than one-third the breaking weight produces a permanent set; that, in fact, any weight laid on a beam produces a set, though proportionately small. Any deduction from the production of a set is fallacious.

It appears by experiments made by Colonel Beaufoy, at the Dock Yard, at Deptford, that the deflections of beams of oak, fir, and pine, were very nearly in the ratio of the weights, until about half the weights had been laid

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on, after which they became more rapid; from which Mr. Barlow seems to draw the conclusion, that a piéce of timber will safely bear about half the weight which is necessary for producing its ultimate rupture. I should, however, mention, that in the building of dwelling-houses, the strength of the beams, and the consequent dimensions, must not be calculated with relation to the breaking weight, but to the degree of flexure of the beams which may be permitted without endangering the ceilings under the beam.

Pillars with flat ends should have their breaking weights at least four times greater than the weight they are intended to bear, as it is not always possible to ascertain that the ends of the beam are properly bedded, or that they will remain so, if the foundation on which they are placed should settle. And as appears from Mr. Hodgkinson's experiments, a pillar with rounded ends is only capable of bearing one-third the breaking weight which a pillar with flat ends would; and a pillar improperly fixed has its strength reduced at least to that of a pillar with rounded ends, that is, one-third. Therefore, if a pillar with flat ends (and the inferiority of pillars with rounded ends being known, they will seldom be used) have not its breaking weight three times greater than the weight to be borne, any negligence in fixing, or settling of the foundation, might cause the pillar to be broken by less than the weight it was intended to support.

Mr. Ward concluded by recommending that the members of the Society, especially those interested in mines and maufactures, should preserve the records of such structures, beams, or pillars as might be broken in their works, with the data requisite for calculating the strength, the weight causing fracture, and the situation and the time which the structure had stood before breaking, in order to furnish more precise knowledge on the points to which he alluded.

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The following Paper was then read:—

ON THE MORE DISTINCTIVE CHARACTERS OF ANIMALS AND VEGETABLES. BY J. D. HEATON, M.D., OF LEEDS.

The object proposed in this paper is to notice, briefly, the various particulars in which animal beings are regarded by naturalists as most remarkably differing from those which possess the inferior organization of a vegetable, and to show that, in respect of each of these distinctions, exceptional instances occur in the case of some species, so that none of these are capable of affording grounds for an exact scientific definition between the two great kingdoms of organized nature, and that such a definition cannot be established.

1. The first points of difference mentioned as generally pevailing between plants and animals, were the evident particulars of *form*, *size*, and duration of *existence*. The animal usually presents a bilateral symmetry of form, being divisible along the median line into two halves of similar outline; and its limited number of similar organs and parts entirely differs from the complex and irregular branching of a plant. But, to mention no other exception to this general rule, the ramified form of Polypipheræ, entirely resembling that of a vegetable, though unquestionably possessing an animal nature, sufficiently shows that this ground of distinction is far from universal. In connexion with the more definite form of animals, may be noticed their more limited *size* and *duration of existence*. A forest tree may continue to live and flourish for centuries, gradually increasing in size throughout this long period; an animal, on the other hand, soon arrives at its full growth, and its entire existence is limited to a definite period. But in these respects, likewise, the animal zoophytes entirely depart from

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the ordinary rule which prevails amongst animals, and conform to that of vegetables.

2. These more external differences all depend upon one circumstance, viz., that amongst animals, each individual possesses but one seat of independent vitality, and is hence incapable of being divided into parts, each of which shall continue to live and grow; but in an individual plant, the centres of vitality are greatly multiplied and constantly multiplying. Those animals, however, which resemble plants in the particulars above mentioned, resemble them likewise in containing numerous centres of vitality in a single individual.

Animals differ from plants in many peculiarities of *structure and composition.*

3. The tissues of animals differ in their *chemical composition* from those of plants, in containing a considerable proportion of nitrogen, in addition to the oxygen, hydrogen, and carbon of the latter. The *principles* stored up in the tissues of plants may have nitrogen as an essential constituent; but not the *tissues* themselves. But this very general distinction is not universal. The vegetable Fungi contain nitrogen, and some of them have the odour of animal flesh; on the other hand, the animal tissue of the Frustulia salina, a zoophyte, is proved, by careful analysis by Schmidt, to resemble a vegetable in the absence of nitrogen; and the same is true with regard to the Cynthia mammillaris, a species of Ascidia, and, probably, with regard to many other animated forms.

4. The *physical structure* of animal tissues presents the varieties of form observed in microscopical examination of cellular, muscular, nervous, and the other tissues, of which the entire body of an animal is made up. The tissues of plants present an entirely different microscopical appearance, and much more simplicity of structure, being merely modi-

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fications of tubes or cells. But towards the bottom of the scale of organized beings we find, both in plants and animals, the greatest simplicity of structure, and in each kingdom, many which consist only of an aggregation of cells. A large proportion of cryptogamic plants have this simple structure; and amongst animals may be mentioned the different species of Diatoma, Fragillaria, &c., which, from the similarity of their structure, are not unfrequently classed amongst the vegetable Confervæ, but which, in respect of their remarkable powers of locomotion, seem to claim the rank of animals. Certain species of Entozoa have an equally simple structure; the same is true with regard to the Cynthia mammillaris, mentioned above. In the mode of their first development, as observed by Schleiden, and, subsequently, by many other microscopical physiologists, all the tissues, both of plants and animals, are strikingly similar. Dr. Lindley considers the presence of *starch granules* in the tissues of plants to be the most unexceptionable mark of their vegetable nature; but it is, perhaps, doubtful whether starch is developed in all beings whose vegetable nature is fully acknowledged.

Animals differ markedly from plants in some of their *functions*. The functions of vegetables are those of nutrition and reproduction, called the organic, or vital functions; animals possess, in addition to these, those of relation, viz., sensation and motion. This is what Linnæus made the ground of distinction in his brief statement, "*Lapides crescunt, vegetabilia crescunt et vivunt, animalia crescunt, vivunt et sentiunt.*"

5. These animal functions of relation are performed through the agency of a *nervous system*, in the possession of which, likewise, animals differ from plants. No nervous system has ever been demonstrated in a plant; some fanciful botanists, as Braschet, have thought that they discovered

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in the pith the analogue of the nervous system of animals; but nothing can be more improbable; and many perfect plants contain no pith. But, then, there are likewise many animals, *e.g.*, various species of polyps, in which no nervous system has, as yet, been discovered.

6. With respect to the functions, that of *sensation*, in whatever organized being it can be proved to exist, may be regarded as a sufficient proof of its animal nature; but the difficulty lies in the proof. In invertebrated animals, we have no proof of their possessing sensation, except their movements or sounds, when painful impressions are made on their bodies. But are these any better proof of sensation on their part, than are the curious motions of the sensitive plant, and several other evidently vegetable beings, when struck or irritated? Besides, the class of movements to which physiologists give the name of *reflex*, and which cannot be distinguished from those which are voluntary and accompanied with sensation, may take place in the paralysed limb of a human being deprived of all sensation, or in the body of an animal from which the brain has been removed; even in the tail of a lizard separated from the body. As we cannot prove the existence of sensation in all animals, nor even, very satisfactorily, its absence from all vegetables, this will not serve as a distinctive character.

7. Still less will the power of effecting *automatic movements* serve our purpose; for we see this existing in many plants, as the Dioncœa muscipula, the Mimosa sensativa, the stamens of the common barberry, the stigma of various species of Mimulus, &c. Nor yet is *locomotion* an animal characteristic exclusively, nor invariably; zoophytes are rooted like plants to submarine rocks, and oysters are chained for life to the banks on which they grow; oppositely, some of the lowest vegetable forms present strange locomotive movements during certain periods of their existence;

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the Conferva tribes produce reproductive spores, which swim actively through the water till they meet with a convenient locality, to which they attach themselves, and then germinate and grow like plants.

8. The *nutritive functions and apparatus* in animals and plants present characteristic differences. The presence of a digestive sac, or stomach, in animals, and its absence from plants, is frequently stated as one of their most exact distinctions; but if we call the interior of the membranous sac, which forms the entire animal in the case of the hydatid, its stomach, the cavity of a vegetable cell seems to have an equal claim to this distinction. "It is impossible," says Dr. Lindley, "that the whole interior of a living and independent cell is not a stomach." With this ground of distinction, to which kingdom would the Poriphera or Sponges belong?

9. The *chemical action* of animals *upon the air* is likewise directly opposed to that of plants. Animals, by the process of respiration, remove oxygen from the air, and substitute an equal volume of carbonic acid. Plants decompose carbonic acid, and restore the pure oxygen to the air. This is a very general distinction, but not universal. Amongst plants, the class of Fungi form a striking exception, for they resemble animals in their action on the air; on the other hand, the *Frustulia salina*, the curious zoophyte before mentioned, constantly evolves pure oxygen; and it was the observation of this peculiarity which led to the chemical analysis of its tissue.

10. Lastly, there is a very general distinction as to the *nature of the food* required by animals and by vegetables. Vegetables convert inorganic matter into the substance of their own tissues; animals can derive support only from organized substances, or organic principles. But this general rule is not entirely without exception: water,

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common salt, and some other mineral salts, are necessary ingredients in the food of animals; and, amongst plants, the class of Fungi, *anomalous* in so many respects, are so likewise in this, that they feed upon organic principles contained in decaying organized substances.

Some few other points of comparison, or contrast, between the animal and vegetable kingdoms, might be gathered, but these seem to be the chief; and a review of the whole serves only to establish the original statement, that no exact limitations can be laid down as the boundaries of these kingdoms; that the characters of one are imitated by beings belonging to the other. Species alone seem to be exactly defined in nature. All groups, including several species arranged together for systematic purposes, insensibly glide into each other; in the words of Linnæus, "*Natura non facit saltus.*"

The CHAIRMAN then called upon Mr. THORP to read his Paper:

ON THE VENTILATION OF COAL MINES. BY THE REV. WILLIAM THORP, OF WOMERSLEY, NEAR PONTEFRACT.

I shall make no apology for the introduction of this subject before the Geological and Polytechnic Society, as it is certain that the person who would discover any safer modes of ventilation, or even any additional precautions to those now in use, and should succeed in having them generally adopted, would be for ever conferring a lasting benefit upon the mass of our mining population.

Nothing can be more simple than the principle upon which coal mines are ventilated. Atmospheric air descending by one shaft, called the downcast shaft, is made to circulate through the subterranean workings, and to ascend at another shaft, called the upcast shaft. The ascending current of air

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is rarefied and made specifically lighter than the descending current, whether by the men and animals in the pit, the natural temperature of the mine itself, or by a fire placed in the upcast shaft. And the efficiency of the ventilation of the mine will, *ceteris paribus*, be in proportion to the heat of the ascending current in the upcast pit. By the experiments of Gay Lussac, 100 parts of atmospheric air, heated from 32° to 212°, expand 137.5 parts; or 180° of heat expands it about one-third. The rate of expansion or rarefaction is not exactly equal for equal increments of heat, but on an average is $\frac{1}{480}$ of its bulk for each degree of Fahrenheit. If heat be communicated to a particle of air, a change with respect to that particle takes place in the following manner: it becomes expanded and increased in bulk but not in weight, and in consequence rises from among the other particles, and ascends upwards. The moment its gravity becomes altered, and in consequence is rendered specifically lighter than the surrounding particles, it ascends and passes upwards through the surrounding particles. And the moment any particle or portions of air have moved upwards from what heated it, their places are taken by other portions coming out of the interior of the coal mine; which last portions, undergoing the same change, ascend in like manner, having their places taken by other particles; and this alteration continues with a rapidity in proportion to the heat communicated, whether the heat be that of human bodies, stoves, fires, &c. If air be heated to 572°, it will be half the weight of that at 60°, and the downward pressure equal to $7\frac{1}{2}$ lbs. per inch, into the downcast shaft.

It becomes, therefore, an object of the first importance to obtain a rapid and warm current of air in the upcast shaft, and for this purpose a fire is placed in all mines with extensive workings at the bottom of the upcast pit; and here occurs a difficulty not usually acknowledged by the viewers and over-

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lookers of collieries. To afford as good a ventilation of a mine as the circumstances will admit, does not allow of a fire of any size to be placed at the bottom, sometimes merely in a fire pan, or in a grate of any size; but the dimensions of the fire and fire place must be in proportion to the area of the shaft through which the ascending current of air has to rise, otherwise the fuel in the grate not being sufficient to rarefy the whole portion of air in the flue, the rising current of heated air is met by a descending current of cold air, and the circulation is thereby impeded. This is a common defect in the construction of house chimneys, and the smoke, met by the descending current, is borne back into the room. Tredgold's rule for the orifices of chimneys according to the height and magnitude of the fire place is equally applicable to the upcast shaft of collieries, viz., to multiply by 17 the *length* of the fireplace in inches, and divide by the square root of the height of the chimney (above the grate) in feet, and the quotient is the area in inches for the aperture of the chimney.*

I know of no colliery where these conditions are fulfilled with regard to giving full effect to the first force of ventilation, for although it may be necessary to use the upcast shaft for other purposes, still if one fire is not large enough, other furnaces might be added.

The mode in which the subterranean ventilation is effected necessarily depends upon the plan on which the coal is ex-

* Example.—For a grate 18 inches wide:—

The chimney, if 36 feet high, should only have an aperture of 51 inches area, *i. e.* about 7 inches square.

$$18 \times 17 = 306 \div (\sqrt{36} = 6) = 51 \text{ inches.}$$

A fire at the bottom of a pit, having a fire-place 12 feet or 144 inches wide:—

The chimney, 300 feet high (100 yards) requires an aperture of only 144 inches, or 1 foot square.

Therefore two fires, as at Haswell, or three fires, would be required for shafts of 8 feet diameter, and 100 yards in depth.

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cavated. In Yorkshire, coal is wrought in what is called the *long* method. In Durham and Northumberland, now chiefly in panel-work, the air being "*coursed*" up and down each panel, and then from one panel to another.

There are two modifications of the Yorkshire or *long* method, used according as the mine abounds in fire-damp, the nature of the roof, &c. One is with *single* board-gates, the air being drawn from one to another across the benks where the men are working, and is used where there is little fire-damp. Another with double board-gates, the air being coursed up one and down another, and drawn across the benks where the men are working. There is another difference in working the benks; one is to begin at the far end of the works or towards the basset of the coal, and work it out down towards the pits sunk; and the other to begin near the levels, and work towards the basset. In some pits, also, the whole of the air coming down the downcast pit, is sent in one body round the whole of the workings; in others, one-half goes on one side of the pit, and the other half on the other.

It may be true that each of these methods, used only where each ought to be used, may be safe, and that many collieries in Yorkshire have for years been worked under them without any accident; but this does not prove that either of these systems is the best, provided any other can be shown to be safer and equally practicable. The great objection to the Yorkshire system is, that where the whole air sent down ventilates in one body the whole mine, if a considerable explosion takes place in any part of it, nearly the whole of the persons usually perish; the ventilation is stopped, and those who are not burnt or killed by the force of the explosion, are suffocated for the want of pure air. The same objection applies, though with less force, where the air is divided only into two parts; the persons in the one-half exploded must nearly all perish.

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To the late Mr. Buddle, of Newcastle, the British nation is under the greatest obligations for devising a new system of working coal mines in panel-work. For instead of carrying on the coal field winning in one extended area, it is divided into quadrangular panels, each containing an area of from eight to twelve acres, and round each panel is left at first a solid wall of coal from forty to fifty yards thick. Through the panel walls, roads and air courses are driven, in order to work the coal contained within each. Thus all the panels, as to roads and ventilation, are connected together with the shaft. The pillars are twelve yards broad, and twenty-four yards long, the boards four yards wide, and the thirlings or slits from one board gate to another only five feet wide, for the purpose of ventilation.

The advantages of this method are:—

1. That the large solid walls round each panel keep off the pressure from the contained coal.

2. That if any casualty, as to falls, crushes, ventilation, or explosion occurs, the locality of the accident is at once known. When the air is coursed some twenty or thirty miles, if the ventilation becomes obstructed, as is usual in an explosion, it is not easily possible to determine where the disaster occurs.

3. If there be an explosion, it will be chiefly confined to the panel where it occurs, and any irruption of water can, if necessary, be confined in the panel.

In the North of England it has been lately discovered that the quantity of air introduced by a shaft of given magnitude can be very much increased by dividing the underground current into several currents, each taking a different direction; the length of the air-courses in well managed mines has been greatly reduced, and is now rarely more than three or four miles, whilst formerly the air had to pass from fifty to seventy miles between the upcast and downcast shafts. It is, there-

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fore, confidently recommended that an air-drift should be made from each separate panel, communicating with the bottom of the downcast shaft. Now the advantage of this is manifest, for besides the greater quantity of air actually introduced by thus splitting the current, the destruction of life consequent upon an explosion is thereby diminished, provided the panels are of moderate size and do not communicate with one another, as to render it impossible to escape to the bottom of the pit without passing through air affected with the after damp. It may be true that to split the current weakens the force of it, but it does not, if the distance to be travelled is shortened. for the sum of the velocity of the divided currents (and, therefore, the quantity of air admitted into the mine) will be much greater than that of the whole united current, since the fire is exerted in a great ratio upon the shorter distances.

It is an easy thing to have rapid currents in the larger air courses, but the difficulty is to have currents of pure air in the benks, slits, thirlings, &c.; and the further distance any air travels the more impure it becomes, because it is progressively collecting bad air.

In order to divide the air, and use it in the workings in separate divisions, and in the *long* or Yorkshire method, several plans might be adopted. Suppose there are 24 *benks* on each side of the pits to be ventilated, one-half of the air would go to those on the one side, and the other half to the other. These halves might again each be sub-divided into three portions, so that eight benks would be ventilated by every one of the sub-divisions. *(See plate I.)* The air would thus be divided into six portions, each serving and ventilating its own compartment; and if an accident should occur in one, only the persons suffer which are in it, and the air will be renewed six times in a given time, instead of once, as on the present system. The only objection is the small expense of

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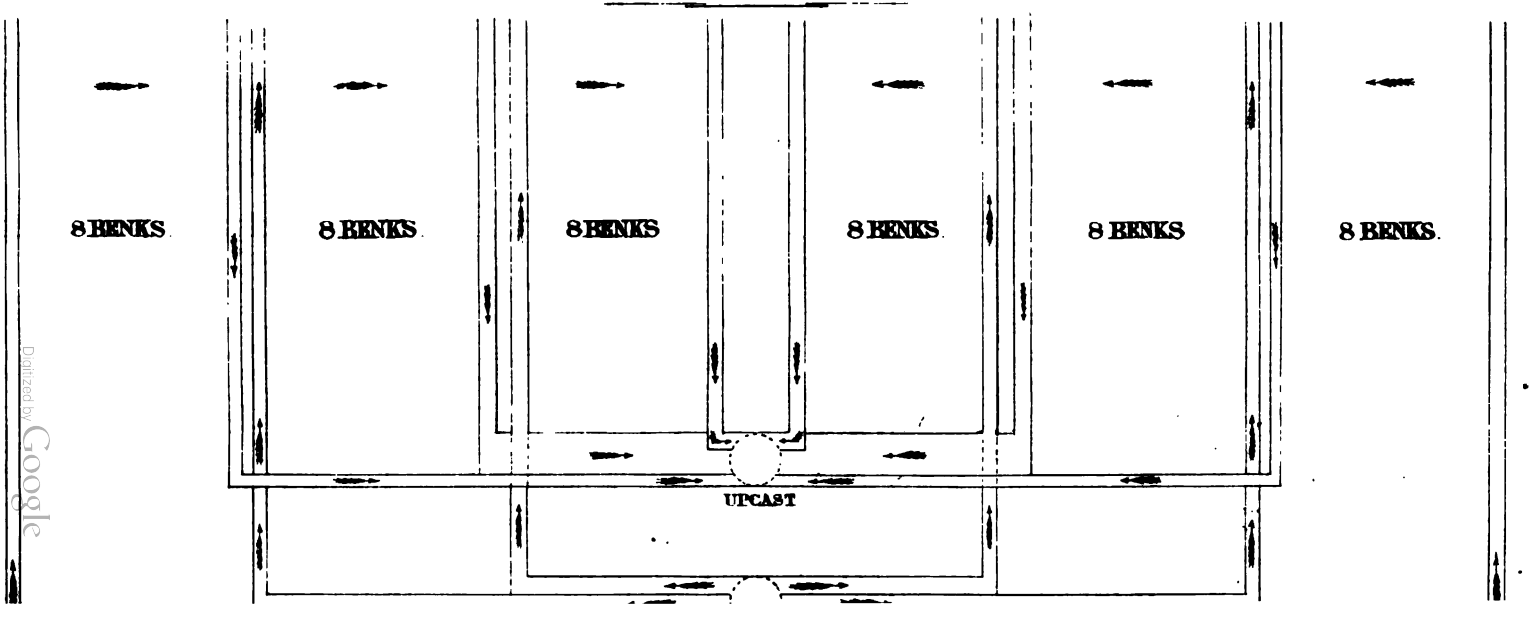
PROPOSED PLAN OF VENTILATION.

To divide the air into 6 portions.



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laying a double tramway (and a triple one for a short distance) in the upper level; and also of dividing the lower level into three roads and two roads, instead of one. The plan, of course, might be modified, but I contend for the principle as being the best and only safe one, and it is equally applicable in long-work as in panel-work. And if the upper level, containing the returning currents, be divided as in the plate, an additional security would be obtained, and any accident could not possibly involve the whole mine.

It is certain that if, at the Oaks Pit, near Barnsley, where 73 persons were destroyed a few days ago, there had been a separate air course from the downcast pit to the workings south of the throw, a great many lives might have been saved. At the Haswell Colliery, in the explosion, (Sept. 28, 1844,) where 95 persons were killed, it is said that if the panel of the Brockley-Whins-working had been a separate air course from the downcast pit, 30 persons at least would have been saved, and who were not very near the place where the mine exploded.

It is maintained by some that by beginning at the far end, as it is called, and working backwards, or in the direction of the dip of the coal, the fire-damp is left behind in the waste or goaf; whereas if the workings be pursued from the levels of the pit towards the rise, the gas follows the workmen up the goaf, and becomes, towards the finishing of the workings, a dangerous magazine of explosive mixture.

It does not, however, seem capable of proof, that after the coal has been worked out, there can be any difference in the state of the goaf, *i. e.* whether the coal has been worked from dip to rise, or from rise to dip. The roof will fall in to the same amount, and in the same form and shape in both ways; and when the excavations are completed, will rise to the highest portions of the goaf.

The accidents in the Barnsley or Thick Coal have arisen chiefly from using single board-gates, when the circumstances

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of the mine required double ones; for when the latter are used and kept well in advance of the benks, they will nearly drain that coal of its gas before the hewers in the benks come behind. For the "*slines*" of the coal (lines of cleavage running in the direction of the "*end*," or nearly north and south), and which always contain, especially in this seam, large quantities of gas, are thus previously intersected and relieved before the following up benks arrive, so that there is less gas comes out of the face of the coal, and less to escape into the goafs. But if single board-gates are used at 40 or 50 yards apart, they cannot be kept much in advance of the working of the benks, (simply because their intercommunication is by means of the benks,) and, therefore, the *slines* cannot be cut across much in advance of the main workings, and where there is much gas the accumulations in the goafs thus become very dangerous. *See Plate II.*

There is no person who understands better the ventilation of the Barnsley or Thick Coal than Mr. Sutcliffe, the intelligent manager of the Gawber Hall Colliery; and he has both the single and double board-gates used, according as certain localities of the mine are more or less affected with gas. He has also a most excellent mode of ventilating his goafs, and which is directly opposed to that now so prevalent of keeping the air "dead" in them; and it is to leave all the "slits" open into the goafs on the windward side, and all walled up on the leeward side, excepting the one in use and the one next to it, which last is kept partially open. Thus the upper end of every goaf and next the workmen is always free comparatively of fire damp, according as the general circulation of the mine will permit. As a proof of the excellency of Mr. Sutcliffe's plan, and the general care which he has exercised over the colliery, he has, at all times, this pleasing and very solacing reflection, that in a period of twenty-four years, in a most extensively worked colliery, he

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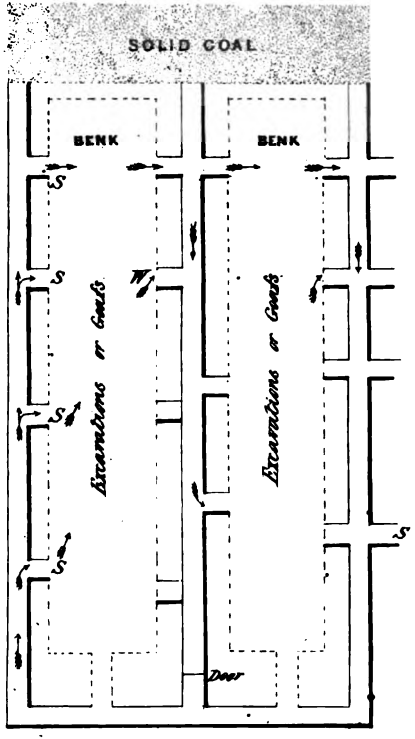
PLAN OF SINGLE BOARD-GATES.

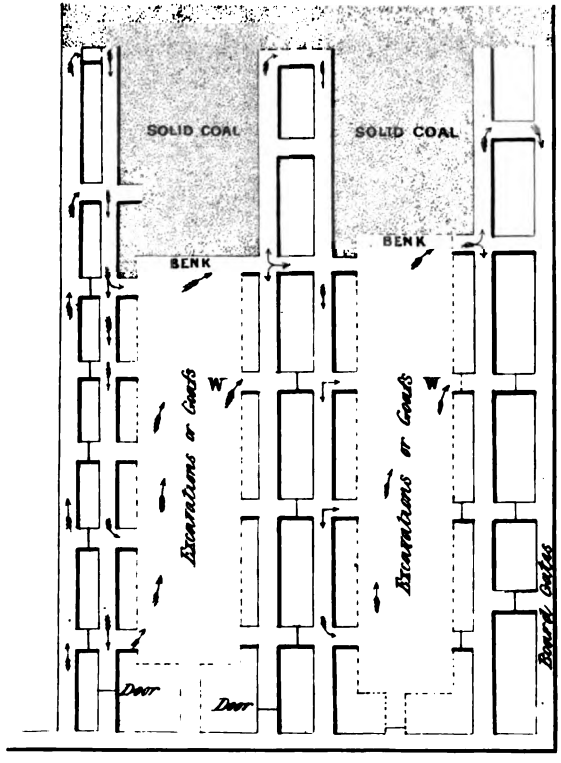
Not in advance of the Benks



S Slit open on the Wind-ward side all the opposite ones closed except the

PLAN OF DOUBLE BOARD-GATES.

in advance of the Benks, returning the Coal of its Gas before the approach of the latter.



Slits same as before

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has only lost, by the effects of fire damp, one man! while in the neighbouring pits in the same coal there have been lost as follows:—

Oaks Pit	72, and 3 at a former explosion.	
Messrs. Horsfall's	6, and 3	ditto.
Worsbro' Park	10	
Messrs. Day and Twibell's	15	
Messrs. Hopwood's	3 at least.	
Total	112	

But, nevertheless, double board-gates are not sufficient for every seam of coal, since they are in general use in nearly all mines in Yorkshire, excepting the Barnsley or Thick Coal. They are in use at Mr. Smithson's Colliery, near Wakefield, yet not one candle is allowed to be used in that pit. If a seam be full of "*slines*," they may be sufficient; but in several beds, the Haigh Moor especially, there is much gas in the stone roof. Other coal beds have gas in the cells of the coal itself; and others again have very few partings or divisions. And, therefore, separate air courses, with separate roads for returning currents of air, are required, just as much as several separate main drains will unwater an estate better than one circuitous and meandering one can possibly effect.

Owing to the fire-damp being lighter in weight than atmospheric air, there is a constant tendency of this gas, (particularly if the coal bed rises at an acute angle,) to creep along the roof to the upper and higher portions of the excavated mine, and thereby accumulating to form a most dangerous magazine. Nearly one-half of the explosions which occur are from accumulations in the goaf, either from gas arising there spontaneously, or by its having drained there from other parts of the mine; and these goafs become sources of great danger, because they are always ready to add the contents of their reservoir to any small explosion

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near them, or to send forth their gases upon any change in the atmospheric pressure around them.

To understand the danger of goafs it is necessary to know that fire-damp is a compound of hydrogen and carbon, or one volume of vapour of carbon and two volumes of hydrogen condensed into one volume. Thus in numbers:—

	Specific Gravity.	
1 volume of gaseous carbon	= 0.4166	0.75 = 1 prime.
2 „ hydrogen	= 0.1388 (0.125 × 2)	= 0.25 = 2 „
	0.5554	1.00

This explosive mixture sometimes also contains a small quantity of olefiant gas and of sulphuretted hydrogen gas, and the mixture when pure is about half the weight of that of air; and, as Sir H. Davy has stated, any mixture of air containing from $\frac{1}{5}$ to $\frac{1}{16}$ of the gas will explode. These mixtures are from 6 to 17 times greater in volume than the fire-damp in them, and evidently not much lighter than air, (0.91 and 0.96.) Hence to take away one cubic foot of fire-damp, is to prevent the formation of from 6 to 15 feet of explosive mixture. When sub-carburetted hydrogen is mixed with twice its volume of oxygen and exploded, we obtain exactly its own bulk of carbonic acid, while water is precipitated, so that a perfect choke-damp is formed by the explosion. Of the two volumes of oxygen, one remains gaseous in the carbonic acid, and another is condensed with two volumes of hydrogen into water.

The explosion at Haswell was from the firing of a goaf 13 acres in extent, the thickness of the seam of coal being $5\frac{1}{2}$ feet; and as the country had not generally sunk in, there was supposed to have been left a vault $5\frac{1}{2}$ feet high, and 13 acres in extent. The coal seam was not quite horizontal, but rose 1 in 24. Messrs. Lyell and Faraday suppose that at the lower edge of this goaf nothing but air might be present, and likewise for a considerable distance up into the

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vault; yet at the upper edge, a mixture of gas and air, and even a highly explosive mixture, might be escaping: That in mines subject more or less to fire-damp these goafs give out gas into the workings by a gradual underflow in smaller or larger quantities under ordinary circumstances; and sometimes suddenly, and in great proportions, on extraordinary occasions: That the fire at Haswell took place close to the goaf of the Meadows working, the issue of gas being probably caused by an extensive falling in of a considerable area to the surface, and that the goaf of the High Brockley Whins working increased the conflagration.

At the Oaks Pit, near Barnsley, the explosion took place from a goaf of about three acres, although the Pit has only been working three years, and there are not yet excavated above twelve acres. A man was working within sixteen yards of this goaf known to be full of inflammable air, with a naked candle; and it appears from the evidence at the inquest, that he had gone towards it with his candle, for he was found dead half way between the place of working and the goaf. About one-half of the persons were either burnt to death, or killed by the violence of the explosion; the other half, or at least one-third, were suffocated by the after-damp or carbonic acid formed from the explosive mixture.

The explosion at Mr. Horsfall's Pit, in Worsbro'-dale, is another recent example of the danger of goafs.

Sudden irruptions of gas from goafs into the workings may be produced by three causes.

1. If the goaf cavity is full to the highest edge level, the mechanical fall of the roof will drive some portion of gas or mixture into the workings of the mine.

2. As named by Mr. Buddle before the Committee of the House of Commons in 1835, that gas from an upper seam of coal, when the strata fall in and fill up the goaf, is often emitted downwards.

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3. From a low state of the barometer. Mr. Buddle stated that accidents from fire damp always occur with a low barometer. In the Haswell High Meadow goaf of thirteen acres, supposing the area above not to have tumbled in, and the whole coal space empty, a fall of $\frac{1}{10}$ of an inch in the barometer would have forced out 7.550 cubic feet of gas below the edge of the goaf. Again, suppose that the ground above had fallen in so as to leave the air space in the goaf not more than one-quarter of the volume of the coal removed, a fall of $\frac{1}{10}$ of an inch would still permit 1.887 cubic feet to issue forth. Hence the goaf, in connection with barometric changes, ought to be carefully attended to.

The method of working the coal so as to "leave the air (gas) dead," is now much pursued in Yorkshire. It consists in the admission of as little atmospheric air as possible into the goaf, and of confining it to the faces of the coal, and other parts of the mine where the men are working. The goaf is made to follow immediately upon the heels of the workmen, and all the slits or inlets into it are immediately walled up, so as to exclude the entrance of air. The principle upon which this plan is accounted to be safe is this:—That fire-damp will not explode without a certain admixture of atmospheric air, as before stated; so that a candle may be placed inside of a gasometer, and it will immediately be extinguished; and it is said that streamers of gas issuing from goafs thus conducted into the air-passages will readily ignite, but not explode the goaf itself.

If the fire-damp were not an elastic fluid, and did not expand from the causes before detailed, and could always be restrained within the limits of the goaf, then this plan would be perfectly safe. But, as occurred at the gas works at Barnsley, in repairing a drain near the gasometer, owing, perhaps, to a low barometric pressure, the gas becoming more mixed, ignited the great mass, blew up the place and the man

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who fired it to atoms, the report being heard several miles. And if an explosion to a moderate amount should occur, these goafs add their accumulated reservoirs to the general conflagration. For at any explosion the fire-damp suddenly and violently expands to *three-and-a-half* times its former bulk; pressing equally on all sides, it drives the gases out of the goafs wherever its influence is exerted,—blows down everything before it,—and expends its force where there is the least pressure,—and usually makes an exit at one or both of the shafts. The state of a colliery in such circumstances was significantly described to me by Mr. Gooddison, (Mr. Charlesworth's viewer,) by saying "It was always to keep our gunpowder too damp to take fire." "Yes," said I, "but if it should become dry enough, or if a partial explosion forces your gunpowder out of its magazine, it at once dries and ignites it, and a general conflagration is inevitable." Besides, it is impossible to keep, or know that, the fire-damp in these places always contains less than $\frac{1}{7}$ of, or more than $\frac{1}{16}$ of atmospheric air; or whether it is in an inflammable state or not. In mines thus ventilated, no naked candles should be permitted.

There is one more source of danger frequently occurring in coal just laid bare, and particularly in the neighbourhood of small faults, that is, from sudden small outbursts of gas, called *blowers*. The explosion at Killingworth, on the 16th of April, 1845, is an example. These blowers give no notice of their approach, and frequently emit during the night, &c., a very considerable quantity of gas. It is usual, in board-gates, for the men to fire the gas which has thus accumulated; but in the neighbourhood of goafs, or when the whole ventilation of the pit is not very perfect, it is a dangerous experiment.

In conclusion, I beg leave to suggest some methods which are calculated to diminish the risk of accident.

1. I am firmly convinced that no great improvement can

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take place in coal-working generally without *Government surveillance*. The trade is hardly now remunerative; all are struggling to bring coal into the market at a low price, and such a state of things is not likely to foster any improvement; but the lives of thousands, and the well-being of the population of large districts, are involved, and it is the duty of Government to watch over and protect these. An absolute rule, therefore, ought to be made, that the ventilation in every individual mine in the kingdom should be conducted on the best principles known; and the safety of those employed should be secured by insisting upon all reasonable means of preventing accidents, and which should be equally enforced upon all.

2. The *size of the furnace* should bear some proportion to the area of the upcast shaft. This fire being the prime mover of the ventilation, will, if duly proportioned to the chimney, produce accelerated velocities of the air in different parts of the mine. It would be impossible to work 1000 acres with a single pair of shafts, as in the North of England, if, as is frequently the case in Yorkshire, a small fire is placed at the bottom of a deep shaft used as a drawing pit, and from eight to ten feet in diameter. A register of the velocity of the air, measured by an anemometer, going into the workings and coming out of the upcast shaft, ought to be daily made and kept.

3. To work *detached portions of coal of a moderate size*, so that no air course shall be of greater length than four miles. Professor Anstead says that this plan is now adopted in all the best regulated collieries of the Newcastle coal-field, and I am certain it might be so with equal advantage in Yorkshire. If the work be not pursued in panels, it is nevertheless easy to have separate air courses to and from different portions of the mine. The air road itself costs nothing, and is paid for by the coal taken out. Suppose the whole body of air admitted by the downcast pit has to travel

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sixty miles at the rate of three miles per hour, it will be twenty hours before it can escape at the upcast pit. But if the same be split into six currents, each will only travel ten miles, and at the same rate will be detained in the mine little more than three hours. Besides, so conducted, a general explosion is impossible.

4. The dangerous nature of the different *goafs* in a mine, requires much greater caution than is usually given respecting them. Their boundaries may vary from—

1. Atmospheric, or barometrical changes.
2. Falls of the ground, or extensive ground weights, as called.
3. From irruptions of gas out of a superior seam of coal, however thin.
4. From a gradual rising of the gas towards the upper and more elevated portions of the mine.

One side of the goaf must necessarily be open, and it is requisite, therefore, that an active ventilation be enforced against or adjoining those portions which are exposed towards the works, and in the next place, that periodically, the precise boundary of the inflammable air be remarked and *registered*. A very simple way of examining the air in goafs, is by having a bottle of the capacity of three or four quarts, made of tin, and having two corks or stop-cocks, filling it with water and emptying it in the goaf, and recorking it at the same place. The vessel will then be filled with air; and if taken to a safe part of the works, may be examined by passing the air through a glass tube to a candle, as, for instance, the chimney of an argand lamp.*

* Professor Graham proposes an instrument to be used which will measure the velocity with which gas passes into a vacuum, this velocity being equal to the square root of the density of the gas. Hence the exact amount of fire-damp in any place could be ascertained.—See Report of British Association for 1845, p. 28.

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5. In mines where the Davy lamp is obliged to be used, it is necessary that the lamp should be cleaned, the gauze of every lamp examined, and locked before being delivered to the men each day, by a competent person. It is usual for the colliers to clean them themselves, but one defective lamp may be sufficient to explode the whole mine; and at any rate they should be inspected before being permitted to descend. This lamp, I believe, when clean, so that no coal dust will adhere to it, is perfectly safe in carburetted hydrogen, but in a mixture of sulphuretted hydrogen, sometimes evolved when pyrites is exposed to the action of water, the Davy lamp is not to be relied upon.

6. One word respecting the resuscitation of those who are rescued from an exploded pit. All sorts of barbarous remedies are adopted; even Mr. Buddle says before the Committee of the House of Commons, that to dig a hole in the ground, and place the sufferer's head in it, covered up by earth, is the best plan in use. The *mode of death* is as follows:—

1. Carbonic acid enters the lungs.
2. The blood passing through the lungs, does not give out carbonic acid and receive oxygen, which is necessary to life.
3. Dark blood, not purified by air, is transmitted to the left side of the heart, and thence to the brain and other organs.
4. The heart continues to act, circulating dark coloured blood, but its actions become gradually weaker, and in the course of a few minutes cease altogether. The heart is the *ultimum moriens*, and ceases to act from impairment of nervous energy—the result of black blood poisoning the brain.

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The symptoms of being choked by carbonic acid are :—

1. Discoloration of the lips and other parts, the result of venous congestion, and of the want of oxygenated blood.

2. Involuntary actions of muscles; convulsive, not accompanied with pain probably; and caused by contact of the dark coloured blood with the brain and spinal cord.

3. Attempts at respiration by the diaphragm and intercostal muscles, lasting, on an average, from a minute and a half to two minutes.

4. When the efforts at inspiration cease, the pulse of the head and arteries is still distinctly to be felt; and the action of the heart maintains the circulation for two or three minutes longer.

5. The heart having fairly ceased to act, death is fixed; —recovery is impossible!

Treatment.—1. If natural respiration continue, leave the patient to himself in pure air.

2. If the efforts of the diaphragm have already ceased, and there be no attempts at breathing, have recourse to artificial respiration without delay. There is no time to lose. In two or three minutes after the last heave of the chest, the heart's action will have ceased, and then all hope is over.

N.B. The artificial respiration to be persevered in even after the normal one is restored.

In order to inflate the lungs, and in the hurry, persons are not to seek for syringes, bellows, tubes, &c. A tube of any kind is to be inserted into one nostril, or roll up a card or piece of stiff paper into a cylinder, and by blowing

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through this, a good substitute for bellows may be made. Then the following points require attention.

1. Avoid undue forcing of air into the lungs.
2. Inflate at proper intervals, imitating the rythm of natural respiration.
3. The inflating tube to be introduced into one nostril; the other, and the mouth, not be closed.
4. An assistant to press back the box of the larynx, so as not to inflate the stomach.

For the reasons stated, I therefore conclude that the protection of the mining population of the West Riding requires:—

1. The interference of the Government, who ought to demand:—
2. A more rigid attention to the exact quantity of air going out of the mine and into it.
3. That the coal be worked in detached portions, with shorter air courses.
4. That the boundaries, and other circumstances relating to all the goafs, be more strictly watched, and duly registered.
5. That the care of the Davy lamps be entrusted not to the workmen, but to agents of the colliery.
6. That the most efficacious means for the resuscitation of those rescued be printed, and made known to all the coal masters and coal viewers.

After a short discussion upon the practicability of carrying out the above improvements in ventilation suggested by Mr. Thorp, the Society adjourned to the Strafford Arms, where an ordinary was provided.

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE THIRTY-FIFTH MEETING, HELD IN THE TOWN HALL, PONTEFRACT, ON THURSDAY, SEPTEMBER 23RD, 1847.

The Right Hon. EARL FITZWILLIAM, F.R.S., the President of the Society, took the Chair, and called upon W. SYKES WARD, Esq. to read the first Paper.

ON A NEW GALVANOMETER, AND ON SOME OF THE PHENOMENA OF VOLTAIC CURRENTS. BY WILLIAM SYKES WARD, ESQ., LEEDS.

In voltaic electricity, apparatus which should accurately indicate the dynamic effect of a current has long been a desideratum. The instruments hitherto used are objectionable for some one of the following reasons:—being either very delicate and expensive in their construction, requiring tedious manipulation, or giving results which at best are only approximative, or which require considerable powers of calculation to reduce their indications to a real value. I believe that the little instrument I have the pleasure of introducing is not liable to any of these objections, that it will assist the mathematician in obtaining the data he may require, and enable the experimentalist easily to record the power which he employs. Prior to describing my galvanometer, it may not be uninteresting to you, particularly to those who are not

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much versed in voltaic science, to describe the instruments and processes by which voltaic currents have hitherto been estimated.

I make use of the term "current" to express the effect which is communicated by conductors, through which electricity is supposed to pass. There is no science in which greater difficulty has been found in using appropriate and unexceptionable names and terms than in electricity. The terms which have been used in most sciences have been such as expressed, or were supposed to be in accordance with, the then theories and ideas. Such theories have since, in many cases, been found incorrect; and the terms have consequently proved not only inapplicable, but detrimental, from their conveying false ideas, which, when once acquired, are with difficulty eradicated or corrected. The best terms in all sciences would be those which should not express any definite meaning at all. But it would be most difficult to fix such terms in the mind. It is, therefore, best to use expressions which have a general meaning, but which do not convey ideas appertaining to any particular theory. The term voltaic current has been generally adopted, and is one of the most unexceptionable; but even in using this term I must beg to be understood not to mean that any fluid, thing, or matter passes, but merely that a cause or force producing an effect is transmitted; and that I do not express any opinion that we have yet any real knowledge of the nature of electricity, though I may on some future occasion have the pleasure of laying before you some speculations or proposed theory on the subject.

The following methods have been used for estimating the force of voltaic currents:—

By observing the length of platina wire, of a given thickness, heated to redness by the current. In this method it is difficult to observe the exact length and degree of ignition,

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and the method is quite inapplicable if both the quantity and intensity be not considerable.

By passing the current through a Breguet's metallic thermometer. This method is much used by some electricians, but, besides requiring an expensive and delicate apparatus, the results of both this and the foregoing methods are affected by the temperature and currents of the air.

By the voltameter; that is, by the measured quantity of gas evolved per minute from the decomposition of water. This method requires a somewhat tedious observation, and is only applicable to the measurement of currents of considerable energy.

By the magnetic needle galvanometer; which, perhaps, I may be permitted to describe somewhat in detail. When a voltaic current is passed through a conducting wire, and a delicately-suspended magnetic needle is brought near it, the needle will exhibit a tendency to place itself at right angles to the wire. If the current be supposed to proceed from east to west, and the needle to be placed above the wire, the end of the needle, commonly called the north pole, will point to the north. From this fact Dr. Faraday, being anxious to avoid the false nomenclature of positive pole and negative pole, has named the terminals of voltaic circuits anode and catode,—that is, the way up and the way down; and in relation to the idea of electric currents passing in the apparent direction of the sun round the earth, and causing the phenomena of terrestrial magnetism.

The needle does not, however, place itself at right angles to the conductor in obedience to repulsion, as appears at first sight to be the case, but really from an inclination to revolve round the conducting wire. This was pointed out by Dr. Faraday amongst his earliest discoveries.

It was soon discovered that if the conducting wire were bent, so as to pass both above and below the needle, the

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effect thereon was nearly doubled; and that when many folds of wire were coiled in like manner, the effect was increased by each coil. This is the ordinary form of galvanometer.

If two needles be connected one above the other, so that one be within the coil and the other above, the ends being reversed, the effect is increased; as both the needles are affected by the current, and the directive influence of terrestrial magnetism is neutralised. From the latter circumstance this arrangement is termed the astatic galvanometer. The astatic galvanometer may be constructed so that the needles move on a horizontal, instead of a vertical, axis, as in the form adopted by Messrs. Cooke and Wheatstone in the electric telegraph now in general use.

These galvanometers are usually furnished with graduated indices, marked with degrees of a circle, and in many cases are extremely useful for the measurement of weak or moderate currents; but are liable to the material objection that the deflections produced are not in the ratio of the degrees indicated, but in a complicated ratio of tangents of the angles indicated, and of the distance of the needle from the coil further complicated, as the coil does not represent a mathematical line, and by the magnetism of the needle not being strictly permanent.

The torsion galvanometer is an astatic needle, suspended by fine fibres of silk. This may be made exquisitely sensible, and its indications, as dependent upon the torsion of the fibres, are very consistent; but it is, unfortunately, not easily applicable when energetic currents are to be measured, and it is an expensive instrument, and liable to be deranged.

Electro-magnets have been used to estimate energetic currents, by observing the weight which the keeper will sustain; and electro-magnetic machines have also been employed. These are not very easily applicable, as very slight variations of the distance to which the keeper is allowed to

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approach makes a material difference; and even the polish of the surfaces, if in contact, produces a disturbing effect.

A very good instrument has been formed by floating a small bar magnet perpendicularly in water, like a hydrometer, and placing a coil of wire around it; or by suspending a bar magnet from one of the arms of a balance, and in like manner placing a coil of wire around it. These instruments possess many of the advantages of the new instrument I produce to you, but are much more expensive and difficult to manage.

Being engaged in a series of experiments relative to the conduction of voltaic electricity, and requiring a galvanometer in addition to the instruments I possessed, and not being able to obtain any instruments suitable for my purpose from the makers of philosophical apparatus in the county, I was led to make the galvanometer before us. The construction being new to me, and, as I conceive, combining simplicity of construction with several other advantages, I shall have much pleasure if it be found useful to those engaged in electrical investigations. My instrument consists of about thirty feet of copper wire wrapped with cotton, coiled upon itself, and cemented with shell lac at the end and side, so as to retain its form, having the ends of the wire bent so as to form points at which the coil is suspended in a vertical position. The points of the wire dip into two small cups, drilled into the end of two thick brass wires, which serve as supports for the coil; a little mercury being put into the cups. Two arms of wire are attached to the coil, on the ends of which a small scale to contain weights is suspended, thus forming a kind of balance, which, when nicely adjusted, is sensible to about the tenth part of a grain. A common permanent horse-shoe magnet is placed within the coil. Connexions are made between the electrodes and the supports of the coil by binding screws, or otherwise, as most convenient.

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Various coils of wire may be used, according to the quantity of the currents to be measured. With a coil of very fine wire the instrument is moderately sensible, and is applicable when the currents are too powerful to be estimated by the torsion galvanometer.

I believe the instrument possesses the following advantages:

That the indications are by weight, being a direct ratio to the forces of the currents.

That various coils of known lengths and thicknesses of wire can be used, and can be readily changed.

That by using short and thick wires it may be employed for very powerful currents, with little danger of disturbing the polarity of the magnet.

That the magnet being fixed, the indications are not disturbed by the attraction of iron apparatus or of the conducting wires.

That the apparatus is easily constructed, and does not require delicate workmanship.

It will also be readily seen that the apparatus may be employed for ascertaining the relative strength of horse-shoe magnets.

After finding that the instrument worked very satisfactorily in all other respects, I endeavoured to ascertain whether the weights counterbalanced might be regarded as strictly expressing the force or dynamic effect of the voltaic current. For this purpose I had recourse to the method pointed out by Professor Wheatstone, in his admirable essay, printed in the Transactions of the Royal Society for 1843, paragraph 18, page 326.

Feeling some little doubt, however, as to the correctness of Ohm's theory, and of Professor Wheatstone's application thereof, on the ground that it appears to me that the resistance of a conductor is not, in all cases, in the direct ratio of its length, I thought it preferable to make use of another

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method of experimentally adjusting the apparatus, making use of Professor Wheatstone's differential resistance measurer, by which I adjusted wires attached to the galvanometer, so as to have the means of dividing a current, so that exactly half any given current could be passed through the galvanometer coil. By this means I have proved that the indications of my galvanometer are in the exact ratio of the currents passing through it, at all events within the limits of the powers of the batteries which I have tried it with. Thus, if a current through the battery be found to balance 110 grains in the scale, the current from the same battery being divided between the galvanometer coil and the diverting coil, will, within the limits of error arising from the three measurements of wire, be found to lift 55 grains.

Before entering on the consideration of the phenomena of voltaic currents in relation to conduction, I feel it incumbent upon me to draw your attention to the theory of Ohm, which has been universally admired by those who have studied it, and which has become the foundation of the modern applications of mathematics to voltaic electricity. I regret that I cannot at present go very fully into this, as it would occupy too much time, that I have not had access to the original paper, and that I have some doubts as to the strict accuracy of some of the deductions therefrom, which I have not yet had time fully to confirm. I, however, hope shortly to do this with the assistance of the new galvanometer.

The main features of Ohm's theory are simply expressed in the following formula, $F = \frac{E}{R}$, in which F denotes the force of the current, E the electro-motive forces, and R the resistances. These are thus defined by Professor Wheatstone :—

" By electro-motive force is meant the cause which in a closed circuit originates an electric current, or in an un-

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closed one gives rise to an electroscopic tension. By resistance is signified the obstacle opposed to the passage of the electric current by the bodies through which it has to pass; it is the inverse of what is usually called their conducting power.

"When the activity of any portion of the circuit is increased or diminished, either by a change in the electro-motive force, or in the resistance of that portion, the activity of all the other parts of the circuit increases or decreases in a corresponding degree, so that the same quantity of electricity always passes in the same instant of time through every transverse section of the circuit.

"The force of the current is directly proportional to the sum of the electro-motive forces which are active in the circuit, and inversely proportional to the total resistance of all its parts; or, in other words, the force of the current is equal to the sum of the electro-motive forces divided by the sum of the resistances."

This may be rendered more familiar by experiment. If we take a plate of amalgamated zinc and a plate of platinized silver immersed in diluted sulphuric acid, forming the arrangement invented by Mr. Smee, and known by his name, and connect the plates, decomposition of the water takes place, the zinc being oxidated at the expense of the oxygen of the water, and the corresponding quantity of hydrogen being evolved at the platinized surface. By this the electro-motive force E is developed. I will not now discuss the chemical and contact theories of electricity, but merely state the undisputed fact, that the chemical decomposition and electro-motive force are correllative, not only in being simultaneously developed, but also in quantity. Now the force F, developed in every part of the circuit, may be strictly expressed by E, the electro-motive force of the elements, that is, the water decomposed and the

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formation of sulphate of zinc dissolved, (the electro-motive force from the latter is generally supposed to be extremely small,) divided by the resistance to conduction of the fluid, (in technical language, the electrolyte,) and also of the plates themselves, and the conducting wire connecting them. I have selected this form of battery as visibly manifesting these effects, for, on connecting the plates by a short wire, the force F is considerable, and is manifested by the energy of the evolution of gas; but if I introduce a greater resistance into the circuit, the evolution of gas will be much diminished: by introducing the galvanometer into the circuit we obtain an estimate of the force in grain weights supported. If we add a still greater length of wire, for instance, adding a coil of 70 feet, we shall find the evolution of gas again diminished, and in like manner the force as manifested by the diminution of weight supported.

So far the theory is beautiful and unexceptionable; but in further applications of the theory as stated by Professor Wheatstone, "the resistance of the connecting wire of the circuit is directly proportional to its length, and to its specific resistance, and inversely proportional to its section."

Some experiments were made by Mr. Barlow many years ago, but which were imperfect, both from the construction of the batteries employed, and from not taking into account the resistances of the battery itself, (Ohm's theory being then little known.) From these experiments it appeared that the resistance was directly proportional to the square root of the length of the wire, and inversely proportional to the quantity of metal contained in the wire.

Some experiments confirm these views, particularly when the resistances of the battery are not estimated. The results of my own experiments, which are not yet so complete as I desire, lead me to suppose that the same law of conduction does not hold in regard to currents of consider-

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able quantity, as in regard to currents of considerable intensity and slight quantity.

Such experiments demonstrate the utility of employing an instrument the indications of which are in strict relation to the forces of the current; if the ordinary galvanometer had been employed, it would have been much more difficult to ascertain whether the instrument or the theory was at fault.

Having received some intimation or suggestion, I think from a paragraph in a newspaper, that two voltaic currents might be passed through the same conductor, it appeared to me that if it were proved that two currents could pass through the same wire in opposite directions, and without interfering with each other, such fact might lead to important inferences in the theory of electricity, and that, at all events, the result of experiments on this subject might be of some importance in ascertaining the conducting power of the various bodies. Having at hand several coils of wire 200 or 300 yards in length, and also electro-magnets, I passed a voltaic current from a series of very small plates through about 300 yards of thin wire, and also through the coil of wire of an electro-magnet, consisting of about 30 yards of much thicker wire. A moderately delicate galvanometer was connected with the small wire, and formed part of the circuit; and a pint cell, according to Daniel's arrangement, was connected with the coil of the magnet, and I did not find that the deflections of the galvanometer were sensibly affected by the more powerful current passed through the coil of the magnet; and it appeared that two currents might be passed in the same, or in opposite directions, through the same conductor, without interfering with each other. I then varied the experiments, passing currents from two small voltaic pairs through considerable lengths of wire, sometimes in the same, and at others in the con-

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trary, direction, a galvanometer being introduced between the long wire and the pair, which may be designated No. 1. I found that although the galvanometer was deflected by the current from No. 1, yet the current from No. 2 in one direction increased the deflection, in the other diminishing it.

Being desirous of knowing whether such experiments were at all new, I mentioned some of the results to my friend, Martyn J. Roberts, and was by him referred to the notice of a communication by Mr. Gassiot, published in the Transactions of the London Electrical Society. Mr. Roberts also mentioned that he had, some years ago, tried experiments of a similar nature, and that he was of opinion that two currents could not be passed in opposite directions through the same wire by any arrangement which was free from suspicion of fallacy, arising from the action of one series of elements on the other.

Finding the inferences drawn by Mr. Gassiot and the opinion of Mr. Roberts at variance, but not being acquainted with the precise manner in which the experiments of either were conducted, I made a considerable number of experiments, making use of coils of copper wire of 100 feet in length, and of the thickness known as No. 20 of the Birmingham wire gauge, or .035 inch.

Mr. WARD then detailed numerous experiments, the results of which were exhibited on diagrams, and stated that he had arrived at the following conclusions:—

That currents cannot pass along a conductor in opposite directions; that the appearance of their doing so is due to the transmission of the current from one pair or series of elements to the other; but that, on the other hand, the conducting power of wires is diminished to the amount of current passing through them.

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At the conclusion of the paper, a brief but interesting discussion took place, arising out of some suggestions by Mr. Morton. The first of these suggestions was very important in its bearing upon the preservation of human life, namely,—Whether it was not desirable that men conversant with the science of galvanism, (instancing Mr. Ward in particular,) should direct their attention to experiments to ascertain whether it would be possible to produce light without flame, for use in coal mines. Another suggestion had for its object the consideration of the propriety of experiments directed especially to ascertain whether it would be practicable and economical to apply galvanism to motive forces and the raising of weights.

The Noble CHAIRMAN remarked that the importance of the former suggestion had been painfully impressed upon the people of this part of England within the last few months.

Mr. WARD said his attention had been already in some measure directed to the application of magnetism to the purposes in question, and if it would be of any advantage to the society, he should be glad to pursue his investigations further. The result of his experiments hitherto led him to fear that, even if the instruments were perfect, voltaic currents would be an expensive means of obtaining mechanical power. With regard to lighting coal mines by light without flame, he stated that a patent had some time since been taken out with that view, but he expressed his opinion that galvanism would be an inconvenient means of effecting that object, it being necessarily attended with a cumbersome apparatus.

With regard to the application of galvanism to the electric telegraph, (which formed the subject of another suggestion from Mr. Morton)—

Mr. WARD said that he should be glad, on a future

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occasion, to bring forward some of his own experiments, which he could not do until he had specified a patent.

The Noble Chairman now called for the next Paper

ON THE POLICY OF PROMOTING AND ENCOURAGING THE GROWTH OF FLAX IN GREAT BRITAIN AND IRELAND; AND AN INQUIRY WHETHER FLAX CAN BE PRODUCED (lb FOR lb) AS CHEAPLY AS THE COST OF IMPORTED COTTON. BY HENRY BRIGGS, ESQ., OF OVERTON, NEAR WAKEFIELD.

It is maintained by many individuals that there is no such thing as positive evil in existence; that the indulging in a contrary opinion would, in fact, be a reflection upon the wisdom and beneficence of the Divine Being; and that those events which we call evils are, in reality, only blessings in disguise, or, as the poet expresses the sentiment,—

"All nature is but art, unknown to thee;
All chance, direction, which thou canst not see;
All discord, harmony, not understood;
All partial evil, universal good."

It may, probably, be rather a difficult task fully and cordially on all occasions to subscribe to these doctrines; yet still, it must be acknowledged by all thinking men, that few events occur, however afflictive to individuals they may be, without their being the means of accomplishing some good end. And we may fully agree with the expression of the poet, in the last line of the quotation, if we qualify his meaning by presuming that he intends to convey the idea that partial evil *results* in universal good.

That our common country has, within the last twelve months, experienced a grievous visitation in the failure of the potato crop, which produced a partial famine, with its attendant evils, particularly in Ireland, cannot be gainsaid;

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and we must all endeavour to make a right use of these afflictions. To the farmer this reads a lesson peculiarly applicable. It is undoubtedly his province to provide food for the country; and he is amenable to the moral obligation to use every available endeavour once more to spread smiling plenty over the land. I confidently apply to the position of the nation at large the foregoing doctrine of the beneficial effects of afflictive dispensations; and cannot but trust that the ultimate results will be to stimulate our agriculturists to renewed and increased exertion; to urge them forward in attempts to discover new and improved modes of culture; and will be the means of introducing from other countries, and acclimating in our own, plants and esculents suitable for the sustenance of men and animals, which are not only more prolific in their increase, but will produce a greater quantum of nutriment per acre. Thus literally fulfilling the idea of the poet before quoted, — deducing from "partial evil," "universal good,"—or, as he elsewhere expresses it, "From seeming evil, still educing good."

But the main object of my introducing these reflections, is to pursue this train of reasoning, and to make a few observations upon the effects of what may be considered as a national afflictive dispensation of a similar nature: I mean the partial failure of the cotton crop in America, and the consequent great enhancement of price of the raw material of a most important branch of our national manufacture, and one which provides employment for so large a portion of our operative classes. I believe it may be considered as an axiom, that the increase of price of any article of consumption has the effect of limiting the demand; and that if any substitute can be introduced which will be as effective at a lower price, or more effective at the same cost, the substituted article will gain the ascendancy, provided the former should retain its high price.

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That the scarcity of cotton, and its consequent enhanced price, has diminished its consumption, is abundantly notorious; and the greatly curtailed hours of labour, with the attendant curtailment in the amount of wages paid, are now having their baneful effect upon the operatives employed in that branch of manufacture. It may certainly be urged that the high price of food has been the main cause of the diminished demand for manufactures of all descriptions,—and no doubt it has had its effect. But even with this greatly decreased demand for cotton goods, the raw material has much increased in price; and had no scarcity of food occurred, and the consumption of that description of goods not diminished, it is obvious that, with the present scarcity of cotton, a much greater advance in price must have occurred than has taken place.

Under these circumstances we naturally look around for some substitute which may fulfil the conditions before-mentioned,—either costing less, or being qualified to produce a superior fabric at the same price. And it appears to me, from all the information which I can obtain on the subject, that, probably, Flax is the material most likely to afford these desiderata; and that, as cotton formerly, in a great measure, superseded the use of flax, so the latter may again obtain the ascendancy, or become a formidable rival. From the much higher price that fine flax has hitherto commanded, as compared with cotton, such an idea may at first view appear Utopian; but, from the reports published by Mr. Warnes, of Norfolk, and Mr. Dickson, of London, both of whom have had practical experience in the cultivation of flax, the profits derived by those growers who manage their crops judiciously, are so satisfactory as to justify the hope that a good quality of flax may be afforded at even a lower price than cotton, and still yield ample remuneration to the producer.

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But again, it may be asked, would it be good policy to promote the growth of flax in England, and would it not exhaust and deteriorate the land? In the first place, I conceive that there can scarcely a doubt arise as to the benefit to be derived from the production at home of the raw material of any extensive national manufacture, if it can be grown as cheap, or cheaper, and of as good quality, as that which is imported, particularly when the most considerable item in the cost consists of labour. And as to the fear of flax being an exhausting crop, I believe I may affirm that both theory and practice totally discountenance the idea, when its cultivation is conducted upon proper principles. But then, again, the objector may urge that the raising of food for man and animals is the natural use to which the soil of England should be applied, particularly as our annual consumption increases in so great a ratio. At first view there seems to be some cogency in the argument; but I contend that *as*, or *if*, we must import either *food* or *flax*, it would be the best policy to encourage the growth at home of that which will yield the greater amount of profit, and the greater means of employment; both of which conditions, I imagine, will eminently be fulfilled by the production of the latter. In Belgium, flax is called "The golden crop," and "The rent-paying crop," and is notoriously the most profitable in the system of rotation which is there adopted.

With regard to the latter consideration,—as to the exhausting nature of a crop of flax,—I shall institute an inquiry into its deteriorating influence, as compared with one of wheat, first premising that it is generally maintained by agricultural chemists, that a crop may be pronounced exhausting in proportion to the amount of inorganic matter which it abstracts from the soil. Now, I will suppose that in these two instances, the grain in the case of wheat is sold

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off the premises, and the straw retained for the production of manure; and in the case of flax, that the dressed fibre only is sold, and the seed retained for the feeding of cattle, which is thus returned to the soil, along with the refuse of the fibre or stalk, much in the same manner as the wheat straw. In pursuing the inquiry, therefore, which of these two crops is the more exhausting? we must place, side by side, such portion of the produce per acre of each as is disposed of and lost to the land, and ascertain which of the two contains the more inorganic matter, or such as is left after incineration. A fair and average crop of wheat I will estimate at ten loads, or thirty bushels per acre, having an aggregate weight of 1,800 lbs. of grain, and a fair crop of flax, when in the dressed state, at 50 stones, or 700 lbs. per acre. According to Professor Johnstone's Analysis of Wheat, I find that he makes the average quantity of ash left, after incineration, to be 1.87 per cent.; and, according to Dr. Hodges, who has lately very minutely analysed the dressed fibre of flax, I find that it yields only .54 per cent. of ash. On working out the calculation from these data, of the relative quantity of inorganic matter which each abstracts from the soil, I find the result to be, that a fair crop of wheat will take away 33.66 lbs., and one of flax only 3.78 lbs. per acre, making the former about nine times more exhausting than the latter. But, again, on estimating the relative abstraction by these crops of those two most important constituents of cultivated vegetables, and most expensive to restore—potash and phosphoric acid—I find that, according to Sprengel's analysis of wheat, that while thirty bushels will abstract 4.05 lbs. of potash from the soil per acre, dressed flax, according to Dr. Hodges, abstracts none; and while the former takes away .72 lbs. of phosphoric acid, the latter abstracts only .25 lbs.;—thus

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rendering a crop of flax infinitely less exhausting than wheat in one of the above constituents, and only one-third as exhausting of the other.

Again, according to the reports of Mr. Warnes and Mr. Dickson, experience teaches that flax is not a particularly exhausting crop, in as far as they affirm that very fine crops of wheat are produced after its introduction, in the rotation; which, from my own personal observation, I can confirm, in the instance of a most luxuriant and heavy field of wheat, under those circumstances, on the farm of my friend, Mr. John Moore, of Moor House, near Ackworth; and the general fertility of the land is also much increased by the consumption of the seed on the premises, as food for cattle. The mode of using linseed for this purpose is, to form a compound of about ¼ lb. of crushed seed or meal, and ¾ lb of barley, bean, pea, or Indian corn meal, made or cooked into a porridge, and then mixed with chopped hay or straw. I calculate that this compound is equally as cheap as linseed cake, and its nutritive and fattening powers are, I believe, found to be superior, as testified by Mr. Warnes, Mr. Marshall, Mr. H. S. Thompson, and others. The following I consider a fair estimate of the average cost of the compound per ton:—

		£.	s.	d.
40	stone of linseed, at 1s. 6d. per stone, or 48s. per quarter	3	0	0
120	„ bean, pea, barley, or Indian corn meal, at 1s.	6	0	0
	Cost of labour and fuel	0	15	0
Total 160	stones.	£9	15	0

Which amount is full as low as the average cost of a ton of linseed cake; and for an article the genuineness of which may be insured by the consumer, which is, unfortunately,

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not always the case with cake. It may be urged that, provided all the seed and solid refuse of the stem be returned to the land, yet still that a considerable portion of the soluble inorganic matter contained in the woody part of the straw is lost in the process of steeping. That the steep-water, after the immersion of the flax, does contain an appreciable quantity of fertilizing matter, is notorious, from the analysis of it made by Sir Richard Kane, and the experiments detailed by Mr. Dickson; yet still, if proper economy be practised, these fertilizing ingredients need not be lost, but the steeping-ponds so placed as readily to admit of the water being used for irrigation. I understand, however, that an improved and more speedy method of preparing the stem has lately been discovered, by means of tanks containing hot water, which may be so saturated with the rich salts extracted from the flax, as to pay the expense of leading it in barrels on the land, and using it as liquid manure. I look forward to still greater discoveries being made in the preparatory modes of separating the fibre from the woody matter, and cannot help hoping that Chemistry may, at some future period, lend her valuable aid in accomplishing that object more speedily and economically—something in a similar manner to the modern process of bleaching.

Having now, I trust, advanced sufficient to show that the growth of flax is not necessarily an exhausting process, when conducted on proper principles, I shall next proceed to the consideration, Whether it is a profitable crop to the farmer?

The expenses of growing flax have been variously estimated,—by some much too high, and by others below, what I conceive to be the real truth. The proper medium I believe to be about £12 per statute acre, taking into consideration the whole operations, from the preparation of the land to the

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scutching the fibre previous to sale to the manufacturer. The details are as follow :—

	£.	s.	d.		Proportion of manual labour. £.	s.	d.
Rent, rates, and taxes	2	0	0	...		—	
One ploughing before winter	0	7	0	...	0	2	0
Dressing—dragging, rolling, harrowing, and picking	0	12	6	...	0	7	6
One ploughing in spring	0	7	0	...	0	2	0
Interest of capital and use of machinery	0	10	0	...		—	
Harrowing, sowing, and rolling the seed	0	5	0	...	0	1	6
Seed, 2½ bushels, at 7s.....	0	17	6	...		—	
Weeding, 6 women 1 day, at 1s.....	0	6	0	...	0	6	0
Pulling the crop— s. d.							
8 women 1½ day, at 1s..... 12 0							
2 men 1½ day, at 2s..... 6 0							
	0	18	0	...	0	18	0
Steeping, 4 men 1 day, or 2 men 2 days, at 2s.	0	8	0	...	0	8	0
Grassing, ditto ditto	0	8	0	...	0	8	0
Scutching, 50 stone weight, at 1s. 6d....	3	15	0	...	3	15	0
Stacking and leading	0	10	0	...	0	4	0
Rippling or thrashing— s d							
4 men 1 day, at 2s. 8 0							
6 women 1 day, at 1s. 6 0							
	0	14	0	...	0	14	0
Contingencies	0	2	0	...		—	
	£12	0	0		£7	6	0

If the above data are tolerably correct, an interesting inquiry ensues, Whether flax cannot be produced on such terms as successfully to compete in its cost with cotton, and still leave a fair and reasonable remuneration to the grower? Should this be the case, linen may then be extensively used as a common fabric; not as a luxury confined to the more wealthy members of the community, but as an economic, as well as a most desirable and durable, material for both personal and domestic use. Now suppose that £4 per acre be considered a fair profit to the farmer, the produce, in order

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to yield that sum, must fetch £16, which may be estimated in the following manner:—

PRODUCE OF A FAIR AVERAGE CROP OF FLAX, PER ACRE.

	£.	s.	d.	£.	s.	d.
Seed, 20 bushels, at 6s. 6d.....	6	10	0			
Tow	0	10	0			
Refuse, suitable for bedding and manure	0	5	0			
				7	5	0
Leaving the sum of £8 15s. to be produced by the sale of the crop of dressed flax, which may be estimated at 50 stones of 14 lbs., or 700 lbs., at 3d. per lb....				8	15	0
				£16	0	0

If 50 stones of dressed flax should be considered an excessive crop, (which, from Mr. Warnes's and Mr. Dickson's Reports, it is not,) even 40 stones, at 3¾d. per lb., would produce the same money. An excessive crop is the more particularly desirable, from the circumstance that the more crowded the stems are upon the ground, the finer will be the fibre, though the produce of grain or seed will be less; and as the increase is in that particular item in the crop which is the least exhausting to the soil, and at the same time the most valuable, it seems highly desirable to adopt the thick mode of sowing. By sowing three bushels of seed per acre, as much as 70 stones, or 980 lbs., of fine dressed flax have been obtained, with a produce of only 12 to 14 bushels of grain; whereas by sowing only 1½ bushels, only 30 stones, or 420 lbs., of flax of a coarser quality, has been the result, though with a crop of grain amounting to 26 or 30 bushels. Now, taking these as data, let us see the result in point of value. Produce in the first case:—

	£.	s.	d.
Fine dressed flax, 70 stones, at 10s.	35	0	0
Grain or seed, 12 bushels, at 7s.	4	4	0
Refuse, say	0	16	0
Carried forward	£40	0	0

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	£.	s.	d.	£.	s.	d.
Brought forward				40	0	0
Produce in the second case:—						
Coarser flax, 30 stones, at 8s.	12	0	0			
Grain or seed, 26 bushels, at 7s.	9	2	0			
Refuse, say	0	12	0			
				21	14	0
Difference				£18	6	0
Deduct 1½ bushels of seed less sown, at 8s...	0	12	0			
,, 40 stones less flax, scutching, &c., at 1s. 6d.	3	0	0			
,, sundry other expenses, say	2	0	0			
				5	12	0
Total greater value of the thick sown, per acre...				£12	14	0

To which difference may be legitimately added something for the extra exhaustion of the land consequent upon an extra quantity of seed being produced. But, again, another very material advantage ensues from having a thick crop upon the ground, in the weeds being smothered, and the much cleaner condition in which the land is thereby left. At present, I believe, the price of dressed flax varies from £40 up to £120 per ton, or from 5s. to 15s. per stone of 14 lbs., according to its fineness, colour, and quality.

This discrepancy or inequality proceeds, in a great measure, from mismanagement, and hence the great scope that exists for improvement, and encouragement held out for attaining excellence in its production and preparation. I confidently believe that in almost every instance in which loss has been sustained in the growth of flax, it has arisen from the grower either not having had the means, or not having possessed the skill, necessary for conducting the operations in an adequate manner. Let the attention of intelligent and enterprising mechanics be once drawn to the requirements of the farmer,

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in machinery for the dressing and preparing flax, and of scientific men to a more economical and expeditious method of bleaching and promoting the separation of the fibre from the woody matter of the stem, and I have no doubt such discoveries will be made as will very materially reduce the cost of flax in England. The expense and trouble attendant upon the preparation of flax have been supposed to render its cultivation by the farmer little desirable; but should an increased production take place, the demand for better machines and for regular district flax-dressing establishments, would be immediately answered by their production, as in this country the demand for the exertion of talent and energy in any particular direction is always followed by the supply. And if the same or equal talent and ingenuity had been exercised upon the production of machinery for preparing flax for the manufacturer, which have been displayed in the after processes of spinning, the advantage to the country would have been immense. The energetic and indefatigable firm of Messrs. Marshall and Co., of Leeds, to whom the linen manufacture of England is so much indebted, I am happy to say are turning their attention to the preparatory processes of flax-dressing, having purchased an extensive tract of land in Holderness, chiefly with the view of growing and preparing flax, and are erecting an establishment on a large scale, for the purpose of steeping, bleaching, and scutching the stem. When parties so eminently qualified, and so well acquainted with the requirements in connection with the raw material, undertake its production, we may augur well for the proper accomplishment of the desired end.

The dampness of the climate of Great Britain and Ireland is often complained of, and, if a disadvantage in some respects, it ought to be turned to account in those instances where it is favourable to peculiar vegetation, this moisture being highly

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conducive to the prosperous and successful cultivation of flax. But there is another consideration which I conceive to be most important in estimating the advantages of flax culture in a populous country like England, which is, that out of the expense of £12 per acre, incurred in raising the flax and preparing it for the manufacturer, about £4 15s. pays the cost of horse-hire, manure, rent, and taxes, and the remaining £7 5s. is expended in the wages of manual labour; whereas in a crop of corn not above one-fourth of that sum is appropriated to manual labour. According to government returns the annual importations of foreign flax are about 70,000 tons, for the payment for which a sum of about £6,000,000 is sent out of the country. This weight would occupy about 250,000 acres for its production, with an expenditure of nearly £2,000,000 in wages, and a profit to the growers of at least the same amount,—inducements, surely, sufficiently potent to encourage the increased home-production of this important raw material, not only from the dictates of that all-powerful stimulus, self-interest, but from the more worthy motive of patriotism.

For many domestic purposes linen is far preferable to cotton, and is constantly so used, although it has hitherto been so much more costly. I need only allude to the beautiful manufacture, so important to Ireland, of damask table linen, the production of which would no doubt be greatly increased by the cheaper and more extended growth of the raw material. Two other articles would also be much more used than now, if cheaper, being so far superior to their cotton substitutes—I mean brown holland and linen checks, to which may also be added, furniture prints and chintzes. For personal wear, particularly for female attire, linen fabrics would be far preferable to cotton, not only from their greater cleanliness, and the property of not so soon gathering dirt, but from their much greater durability. On appealing to ladies of my ac-

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quaintance whether they should prefer a gown made from a printed cotton muslin, or one of equal fineness manufactured from flax, I have invariably received a reply in favour of the latter, even if it should be somewhat more costly. One great advantage which flax possesses over cotton is, that it becomes whiter by constant washing, and retains a purity of colour to the last, instead of becoming yellow and unsightly, as cotton articles do after a short use. This important property gives a superiority and clearness to printed linens, and a beauty to linen ginghams, which is not possessed by cotton articles of the same kind, and which, added to the less downy quality of the material, produces a brighter look in linen manufactures, and makes them really retain their cleanliness much longer under equal circumstances. The strength of the fibre of flax always produces a texture of greater tenacity, which is shown by the much greater value set upon the thin and open fabrics of cambric and lace, when formed of flax, than when made of cotton. A foreign production, possessing many of the qualities and properties of flax, has lately been introduced into England, called Chinese grass, which has been used not only for the more homely manufacture of ropes, but also for ladies' dresses. The fibre appears to be very fine and tenacious, and probably may be used with advantage for many purposes; but I have not sufficient knowledge of the processes necessary for its manufacture to compare their expense with those required by flax, nor am I aware whether there is any probability of its being successfully introduced into England as a profitable crop, or whether the plant would bear our climate.

Having enumerated some of the advantages of promoting the growth and extended use of flax in England, I will now only briefly advert to the consideration, whether its fabrics can successfully compete in cost with those of cotton. With regard to its price, I think I have shown that, with proper

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management, flax can be afforded, in a state prepared for the manufacturer, at a cost of 3d. to 3¾d. per lb. The price of good American or Georgia cotton has, within the last thirty years, varied exceedingly. At the beginning of that period it was 20d., and about two years ago it had gradually fallen to the very low price of 4½d.; at present, owing to the deficiency of crop, it is from 7d. to 8d. per lb. It appears, therefore, that in comparing the respective cost of the raw material of the two manufactures, flax has an advantage (and occasionally a great one) in point of cheapness; and allowing the after-waste in process of spinning to be twenty per cent. greater than that of cotton, (the actual cost of the operation in other respects being much the same,) still flax may be well able to compete with its foreign rival. I understand that the process of heckling the flax, that is, separating the long from the short fibre, or the *flax* from the *tow*, is about twenty per cent.; which will, I find, bring the price or cost to about the same as that of cotton two years ago. Formerly, the loss from the short fibre which was separated was great; but now machinery for the preparing and spinning of that portion of the raw material has been brought to so great perfection, that yarn of almost equal fineness can be produced from it, and in many descriptions of goods is used, to the manufacture of which formerly only the long flax yarn was appropriated.

I ought, perhaps, to apologise for introducing a subject on which my own personal experience is so deficient; but my great desire to aid in calling public attention to so important a crop as flax, and my firm belief in the power of extension in the linen manufacture as a competitor with that of cotton, and the advantage that would be derived to the country from its promotion, must plead as my excuse. I trust that what I have now said may elicit a discussion from those present who may be more able to do justice to the subject; and I cannot but hope that soon the requisite knowledge will become

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general amongst farmers, and a trial may be fairly made of the stability of the views which I have now advanced.

The Noble CHAIRMAN expressed his opinion that the society was much indebted to Mr. Briggs for his paper. He considered the question of exhaustion an antiquated prejudice. The farmer, in his opinion, ought to cultivate that which he could derive the greatest profit from. There ought to be no fear of the exhausting effects of a crop, if it was sufficiently profitable to supply the means of repairing the injury produced by its growth.

Mr. MORTON remarked that, as to profit, flax seemed, according to Mr. Briggs, calculated to leave to the farmer about the same as a wheat crop. There did not, therefore, appear a sufficient motive for giving the production of the former a preference over the latter. The question seemed to narrow itself into this compass—whether we could grow flax at a cheaper rate than we can procure it from abroad?

Mr. BRIGGS was of opinion that it could be produced cheaper; and, in addition to that, there was the great amount of manual labour required in its production, which was a very important consideration. For £3 spent in manual labour in the production of wheat, £7 would be required in the production of flax.

The Noble CHAIRMAN thought the manual labour required in the production of flax a subject well worthy of consideration.

Mr. MORTON thought that for Ireland, where they had a surplus agricultural population, such a consideration was important.

The Rev. W. THORP then read the concluding paper, "On the valuable Ironstone Mine in the Oolite district of Eskdale."

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This being the last paper, the business of the meeting terminated as soon as it had been read, by a vote of thanks to Earl Fitzwilliam.

The necessity for the evening meeting was, of course, superseded.

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE ANNUAL MEETING, HELD IN THE PHILOSOPHICAL HALL, HUDDERSFIELD, ON THURSDAY, FEBRUARY 3RD, 1848.

The Rev. JOSIAH BATEMAN, M.A., Vicar of Huddersfield, in the Chair.

The REV. CHAIRMAN commenced the proceedings by an appropriate address, and proposed that the following gentlemen be admitted as Members of the Society:—

F. H. RAMSBOTHAM, Esq., Fixby Hall, Huddersfield;
Mr. JAMES RADCLIFFE, Huddersfield;
JOHN BROWN, Esq., Wingerworth Hall, Derbyshire;
JAMES TAYLOR, Esq., Marsden;
RICHARD CARTER, Esq., Halifax;
RICHARD GEORGE HORTON, Esq., Leeds;

Which was seconded by Dr. WILLIAM ALEXANDER, and they were unanimously elected.

The Honorary Secretary (the Rev. WM. THORP) then read a very satisfactory Report of the finances of the Society, which exhibited a considerable balance in the Treasurer's hands, as will be seen by the annexed statement of accounts:

STATEMENT OF THE RECEIPTS AND EXPENDITURE,

From 28th October, 1846, to 28th October, 1847.

DR.				CR.			
	£.	s.	d.		£.	s.	d.
To Balance in Treasurer's hands ..	5	0	3½	By Stationery, &c.	0	13	9
„ SUBSCRIPTIONS from—				„ Advertising Meetings	4	4	0
1 Member for 1838.. £0 10 6				„ Rent of Museum Room, for one year and a half	40	0	0
3 Members for 1839.. 1 11 6				„ Salary of Assistant Secretary ..	50	0	0
3 „ 1840.. 1 11 6				„ Collecting Subscriptions	7	13	6
6 „ 1841.. 3 18 0				„ Postages	4	1	6
18 „ 1842.. 11 11 6				„ Expense of Meetings	2	10	6
20 „ 1843.. 19 7 6				„ Printing Reports of Proceedings, &c.	57	16	2
61 „ 1844.. 39 8 0				„ Lithographing Plates for ditto ..	2	7	6
69 „ 1845.. 44 12 0				„ Sundry Expenses	1	13	5
106 „ 1846.. 68 15 6				„ Cash in Treasurer's hands.....	57	17	11½
50 „ 1847.. 32 7 6							
	223	18	0				
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THOMAS PITT, Esq., moved, and CHARLES MORTON, Esq., seconded, "That the following noblemen and gentlemen be Officers and Council for the ensuing year:"—

President.

EARL FITZWILLIAM, F.R.S.

Vice-Presidents.

THE DUKE OF NORFOLK.	J. S. STANHOPE, ESQ.
THE EARL OF EFFINGHAM.	GEORGE LANE FOX, ESQ.
THE EARL OF DARTMOUTH.	J. W. CHILDERS, ESQ., M.P.
LORD WHARNCLIFFE.	E. B. BEAUMONT, ESQ.
VISCOUNT MILTON.	G. WENTWORTH, ESQ.
HON. W. S. LASCELLES, M.P.	W. BENNETT MARTIN, ESQ.
SIR W. B. COOKE, BART.	J. G. MARSHALL, ESQ., M.P.
REV. DR. SCORESBY, F.R.S.	MICHAEL ELLISON, ESQ.
REV. SAMUEL SHARP.	T. D. BLAND, JUN., ESQ.
REV. THEOPHILUS BARNES.	P. D. COOKE, ESQ.
RT. HON. SIR CHAS. WOOD, M.P.	WILLIAM WEST, ESQ., F.R.S.
T. W. BEAUMONT, ESQ.	R. MONCKTON MILNES, ESQ., M.P.

Council.

HENRY BRIGGS, ESQ.	CHAS. MORTON, ESQ.	DR. CHADWICK.
HENRY HOLT, ESQ.	J. W. LEATHER, ESQ.	EDWARD WAUD, ESQ.
DR. HEATON.	J. T. CLAY, ESQ.	T. W. EMBLETON, ESQ.
THOMAS WILSON, ESQ.	J. M. STANSFELD, ESQ.	W. S. WARD, ESQ.

Honorary Secretary.

REV. WILLIAM THORP, Misson.

Assistant Secretary and Treasurer.

MR. HENRY DENNY, A.L.S.

Honorary Curators.

T. W. EMBLETON, ESQ., AND J. G. MARSHALL, ESQ., M.P., F.G.S., &c.

Auditors.

BENJAMIN BIRAM, ESQ., AND G. W. CHAMBERS, ESQ.

JOHN JEFFCOCK, Esq., moved, and BENJAMIN BIRAM, Esq., seconded, "That the thanks of this Society be given to Thomas Pitt, Esq., of Huddersfield, Dr. Wm. Alexander, of Halifax, Phineas Beaumont, Esq., of Sheffield, and J. C. Walker, Esq., of Doncaster, for their services as Local Treasurers; and that they be requested to continue their valuable services."

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The CHAIRMAN now called upon Dr. WM. ALEXANDER to read the first Paper:—

ON THE POWERS OF DISINFECTING AGENTS, AS AUXILIARY TO SANITARY MEASURES. BY WM. ALEXANDER, ESQ., M.D., PHYSICIAN TO THE HALIFAX INFIRMARY AND DISPENSARY.

The great prevalence of an infectious fever, and the introduction to Parliament of a sanitary measure, have of late invested these agents with more than ordinary public interest. They are not proposed merely as antiseptics possessing the power of arresting or preventing organized bodies from passing into a state of decomposition, but the means, as the term would imply, whereby the air especially, and other substances, are to be freed from the taint of subtle particles, sometimes noxious to the sense of smell only, and sometimes to life and health. Their operation, however, is necessarily confined to comparatively limited spaces within and around the dwellings of man, and cannot be supposed to extend to the more widely diffused essence of marsh miasma, nor materially to check the approach of devastating epidemics. They will not dispense with the approved drainage of the land in the one case, nor the well adjusted ventilation, sewerage, and good personal and domestic management best fitted to receive such visitations, in the other.

In order correctly to appreciate the probable influence of disinfectants, perhaps I ought to say something of malaria, a word much employed by medical men to designate a peculiar condition of the atmosphere found to be unfavourable to the preservation of health, and capable at any time, in susceptible subjects, of inducing disease. Of the precise chemical and physical properties of the matter of infection, we are not always well informed. I have much reason to

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believe that aqueous vapour is its ordinary vehicle of communication. Of its occasional sources, the temperatures most favourable to its evolution, the laws which seem to govern its propagation, the extrinsic agencies which modify its action on the animal economy, and of the measures to be resorted to to guard against its absorption, or to render it inert, we are not without light to guide us. But whether it is always one and the same poison, modified only in its operation by its degree of concentration, by caloric, electricity, and the peculiar constitution of the infected, or that there are diversities of malarious virus, is not positively ascertained; though I myself decidedly incline to the latter opinion as best supported by corroborative evidence. Like will produce like, as the seeds of plants reproduce seeds, and the poisonous vesicle or pustule generated in small pox, cow pox, plague, and syphilis, develop these diseases, and no other.

Malaria, in its medical sense, though often associated with stench, is by no means necessarily so; neither is the presence of animal and vegetable putrefaction essential to its generation; though in towns we find abundance of it in the vicinity of obstructed and ill-conditioned sewers. It is more than probable that offensive odors promote its absorption into the human system by their known sedative action; but in the original specific poisons of marsh miasmata, of the Asiatic cholera, influenza, and epidemics generally, we are not conscious of any smell except that which is common to the districts in which they are chiefly found to prevail. Atmospheric dilution commonly diminishes the virulence of aërial poison, and the latest seizures from its effects usually assume a milder form of attack, as though it had spent its powers, or a change had been effected in the electric and atmospheric currents. Actual contact with the infected, in the most avowedly contagious diseases, does not necessarily induce

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them, nor does the absence of this condition confer an exemption from attack; and hence it is often wise in those who have no family ties or social obligations on the spot, to fly from the scene of any spreading pestilence, whilst for those who remain the best protection will be found in the early adoption of judicious sanitary precautions.

Nature's own atmosphere is, I apprehend, the only gaseous medium consistent with the maintenance of health. All deviations, therefore, in its chemical composition and the relative proportions of its own constituent principles, as well as its admixture with foreign solid and aëriform fluids, must be regarded as more or less injurious, according to the degree of variation and their peculiar mode of action. Hence every gas, other than those contained in the atmosphere, may be viewed as poisonous, and unfitted for the due aëration of the blood in its circulation through the lungs. This explanation, if admitted, will enable me to simplify the subject, and dispense with any detailed classification of the deleterious gases founded on their different properties and manner of operation. Some of them, when concentrated or pure, are for a time respirable; others are irrespirable in such a state; some, even when largely diluted with common air, are narcotic in their action; and others of them thus circumstanced are irritants. I do not think there are any possessing negative qualities, although usually so divided. Nitrogen itself, when pure, will soon induce suffocation; and its greater affinity for hydrogen makes it readily quit the atmosphere to form ammonia and cyanogen. If superadded to the air beyond nature's proportions, the effect will be to exclude one-fourth of its own volume of oxygen in any present given quantity, which could not fail to be pernicious if inhalation of it were long continued, for oxygen undoubtedly performs the principal functions in the process of respiration. Hydrogen, like nitrogen, may be inhaled for a very short time, but in

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like manner is unable to effect the necessary change in the pulmonary blood. When mixed with oxygen in the proportion of four to one by measure, it may be much longer respired, but it is with a somnolent and narcotic effect. The various combinations of hydrogen, the common products of animal and vegetable decomposition, are all, indeed, capable of a serious sedative action upon the heart and brain through their influence on the nervous system. In the human excreta and refuse of towns we have a very considerable generation of hydrogen associated with carbon, ammonia, phosphorus, and sulphur, all of which are offensively odorous, and occasionally, when concentrated, fatal in their effects; whilst in milder instances they induce nausea, giddiness, and a lethargic depression of the vital powers. Dr. Leeson's late classification of these putrescent vapours is, I think, open to objection, and would convey an erroneous inference as to the true character of these gaseous compounds, inasmuch as he includes carbonic acid and oxide with the remittent and typhoid miasmata under the head of "dangerous, but inodorous," whilst the combinations of hydrogen are represented merely as offensively "odorous;" whereas of these relative gases when present in respirable equal quantities, the latter are unquestionably the more pernicious of the two, whether viewed as a chemist or tested in medical practice. It is a doubtful assumption, too, to affirm that typhoid miasmata are inodorous; for should they, as I think, consist of minute putrid particles held in atmospheric suspension by aqueous vapour, the probability is that they are odorous.

Carburetted hydrogen, a component of the explosive atmosphere of our collieries, is respirable when mixed with fourteen times its own volume of common air; though colliers as a class, from their mode of labour, bad habits, and foul air, are too often found to be a deformed and short-lived race. All the illuminating gases may in like manner be

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regarded as unfitted for respiration, and capable of inducing narcotic poisoning and diminished vital action.

Of all the volatile combinations of hydrogen in nature, distinguished for their villainous smell, those with sulphur, phosphorus, and ammonia are the most noisome. These are the true products of animal putrescence and feculent discharges. The privy drainage is fruitful of these compounds; and although we find that the daily inhalation of diluted draughts of these gases, when recently evolved, is compatible with health to grooms, tanners, and others, whose occupation is amongst them, yet every day's observation serves to convince me that they are, under other circumstances, highly inimical to animal life. Though not invariably and to all alike equally pestiferous, they ordinarily exert a baneful influence on the nervous centres, if they do not occasion positive illness. I have known fourteen cases of fever promptly induced in a court at Halifax, by the long deferred removal of a single ash-pit cesspool. The experiments of Hallé, Chaussier, and Gay Lussac, all demonstrate the poisonous influence of sulphuretted hydrogen when introduced into the system, either by the access to the lungs, cellular tissue, stomach, or the rectum. They found that atmospheric air, when charged with the 150th part of this gas, proved fatal in a very short time to a horse, one 800th to a dog, and that in the proportion of one 1,500th it immediately destroyed a small bird. Nine quarts of it introduced into the intestine through the rectum of a horse, killed the animal in one minute; and when merely applied to the skin of a rabbit, it died in ten. The hydro-sulphate of ammonia, when undiluted, at once occasions asphyxia; and one or two well ascertained cases have occurred within the last six months, in London and elsewhere, of death from this cause, in which, I believe, the blood was found to be fluid, the muscles flaccid, and the air cells of the lungs filled with

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this gas, as proved by its smell and appropriate metallic tests. In milder forms I have seen nausea, and an approach to coma, with dilated pupil, and a feeble irregular pulse, as the more prominent symptoms, from a like exposure to these noxious vapours, and it is with these elementary and compound essences that disinfectants and deodorising agents are more especially designed to deal, when impregnating the air and other bodies with their peculiar fœtor. The gaseous combinations of carbon operate according to their degree of concentration or proportion of aërial admixture, in a manner analogous to those already considered. But besides being the products of the decomposition of organised substances and the processes of vegetation, we have familiar instances of their generation in crowded close chambers, and in the ordinary combustion of fuel. It is no unusual thing in Dispensary and Parochial practice for us to find rooms in which, from the number of their inmates, the air is so foul, chiefly from having been repeatedly respired, that the flame of a candle affords too small a light *to see* the patient, if we ourselves, coming out of the fresh air, can approach him without being almost stifled in the attempt.

The effects of an atmosphere which will so languidly support the combustion of a taper, will be readily conceived to be irrespirable with impunity by man; and accordingly within the last twelve months, at Halifax, we have had an instance of one common lodging-house of two rooms having had *sixty sick inmates* in the course of sixteen weeks. The head-aches and giddiness frequently experienced from evening meetings, when large numbers of people assemble in limited spaces, arise from the same cause, together with the illumination, which, in neglect of ventilation or any provision for the renewal of the air within, rapidly converts portions of the oxygen present into carbonic acid and oxide, attended by an evolution of carburetted hydrogen and traces of hydro-

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sulphate of ammonia. In all such cases, as in undue exposure to the disengaged gases of vinous fermentation and charcoal fires in other countries, not only is there an unnatural atmosphere generated, but equivalent volumes of vital air are withdrawn, and an admixture of 35 per cent. of carbonic acid is destructive of life to small quadrupeds in about ten minutes. Experiments, indeed, sufficiently attest the poisonous properties of this gas when applied merely to the skin by immersion in it, the ordinary atmospheric access to the lungs being continued. In its pure state, like the irritant gases, it cannot even be inhaled, and suffocation from choke damp is more difficult of removal by timely resort to appropriate measures than when produced by either hydrogen or azote. Did persons but consider that each adult deteriorates by his respiration about 800 cubic inches of air per minute, or 180 gallons of it per hour, and each argand gas burner still more, regard would surely be had to some of the simple modes of ventilation adapted to crowded apartments and public buildings beyond the mere fire-place flues. Equally destitute of smell, the carbonic oxide, though perhaps less directly sedative when inhaled with a necessary admixture of atmospheric air, will shortly excite some mucous irritation, weight in the head, dimness of sight, and giddiness; partly from its direct narcotic impression, but mainly, I apprehend, from its inability to decarbonize the blood.

On the consideration of the other gases, which are chiefly of a corrosive character, we need not just now enter, since, with the exception of ammonia and sulphurous acid, they are not much found free in nature, and have indeed themselves from time to time been suggested as possessing the powers of disinfection. In common with those already mentioned, they are unable to aërate the blood; but some of them exercise, likewise, even when largely diluted with atmospheric air, an irritant action upon the mucous surfaces,

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which renders them almost irrespirable. Their properties, however, will by-and-by claim a passing notice as disinfectants, to which branch of the subject, without further preface, I propose now to proceed.

To dis-infect is, I apprehend, to deprive from the air and other bodies certain known or unknown deleterious or offensive qualities, commonly designated by the terms infection, malaria, miasma, matter of contagion, volatile effluvia, mephitic emanations, and the like, which, founded upon observations innumerable, are productive of disease when communicated to the constitution of susceptible individuals. In this sense of the word is conveyed a comprehensive but not very precise signification. To anti-contagionize might afford in one of these senses a more definite mode of expression, had the word admitted of a verbal form. The wider meaning, of course, best suits the vendor of a disinfectant as a commercial article, being co-extensive with contamination of every kind. The line of distinction, however, which I would at the outset lay down is, that deleterious agencies may be in operation appreciable only by their effects, as well as those which are manifestly discernible by the aid of the sense of smell. Both these kinds of infecting essences may be, and in towns usually are, associated in the origination and diffusion of epidemic pestilence, the extent, type, and character of which will be materially modified in degree as well as form, by the condition as to purity of the immediate surrounding atmosphere, and the previously existing state of health and habit of body of those infected by it. Hence the passage in the Registrar General's late quarterly report, that a cleanly town, when visited by a devastating plague, is somewhat in the position of a city securely built of stone in the midst of a general conflagration; and hence to the like effect are the conclusions arrived at by the metropolitan sanitary commission, as enunciated in their first

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report just issued. It is needless, perhaps, to furnish examples illustrative of this principle, which is familiar with the experience of all observers, and the very recent exemption of Sarepta, a Moravian colony on the Wolga, noted for its cleanliness and well conducted inhabitants, from any visitation by the cholera during the present epidemic, or that which raged along that direct line in 1830, is another instance as applicable to that disease of what we have long known to be operative with respect to typhus. As filth, however, is still elsewhere predominant, it behoves us to deal with it. The media by means of which infecting particles are communicated to the human system are probably various, though not of such a character, I think, as at all to justify the severe restrictions imposed by the quarantine laws now prevalent in the east. The most efficient *cordons sanitaires* I have always considered would be found in an intelligent regard being had to the conservation, by already well ascertained means, of the health and comfort of those at home. That certain porous solid bodies are capable of receiving and retaining within their interstices noxious fluid and gaseous communicable particles, I, as a contagionist under certain circumstances, am prepared to admit; but I believe that under dilution they would ordinarily be harmlessly in contact and respired by persons really possessing an average state of good health; and that it is the low standard of salubrity of those living within the area of confined masses of stagnant atmospheric air, charged with septic vapours, which gives a predisposition to the reception of morbid impressions in these cases, rather than to any peculiar chemical or other affinity subsisting between malarious particles and the respiratory medium of the individual system. In the common typhus of towns these conditions are very obviously traced to a total disregard of sewerage, as furnishing the infecting agent, and of due ventilation as

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indispensable to the healthy performance of the respiratory function. As in the intermittents from marshy emanations, so in typhus, we have a well defined limit in general to its extension, as though the power of the poison had been impaired or even lost by diffusion; and that periodically recurring epidemics, the influenza excepted, should almost invariably select their victims from the same classes of persons, and from the same neglected parts of populous towns, sufficiently demonstrates the intimate connexion that exists between disease and surrounding impurities. As already observed when considering the gases, a distinction should be drawn between the malarious corpuscles which I not only consider to exist, though certainly not endowed with organic life, but to be disseminated by the aid of aqueous vapour, and the simple exhalations of odorous particles. The former I believe to be absorbed, chiefly through the pulmonary tissue, into the circulation, which with Liebig I consider the part of the human organism most vulnerable to exterior influences; whilst the latter effect their access to the body mainly by instantaneous impressions on the olfactory and nervous expansions generally of the mucous membranes. The united operation of these agents of infection I have often seen induce immediate illness; whereas the single action of the first commonly affords an interval or latent period previous to the full development of the poisonous effects engendered by it. In the first case we have what has been termed the organic ferment, whilst in the last the blood does not necessarily undergo change.

I have thus deemed it desirable we should glance at the nature of infecting materials and the channel whereby they may enter to contaminate the system, because on a tolerably accurate knowledge of these points must be founded all rational means of correction. Various, however, as are the sources of contamination, and whatever views may be held as to the precise mode of action in the process of infection,

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the measures recommended for adoption to meet the evil are, speaking generally, such as are comprehended in a well devised national scheme of sanitary improvement. But to particularize, more especially in reference to the immediate subject before us, I shall confine my remaining observations to a brief review of the popular means which from time to time have been suggested to clear the air and other bodies of stench, putrid emanations, the matter of contagion, and the like supposed agents or vehicles of infection.

The means resorted to may be comprised under six sections, viz. first, the prompt removal of all surrounding impurities, refuse, and other sources of obvious pollution; secondly, correction, by thorough ventilation, within and without infected localities; thirdly, by the admixture of certain gaseous fluids with the tainted atmosphere when confined to limited spaces; fourthly, by the aid of sundry chemical agents possessed of exhalent or absorbent properties, by the action of which affinities are brought into force capable of divesting the air or other matters of their offensive odour and noxious qualities; fifthly, by the addition of antiseptics to decomposing materials; and sixthly, by washing, cleansing, and otherwise purifying by exposure to the sun's rays and atmospheric dilution.

On the two first and last of these divisions, though by far the most important, and those upon which, *par excellence*, all other measures should be based, I must forbear to enter as somewhat foreign to my present object, and lest I should be tempted to inflict upon your patience a very long paper on the sanitary question. In limine, however, I would observe, that I do not propose to consider disinfecting gases and deodorizing fluids as in substitution of, but as subsidiary to, sanitary measures generally. Their application is necessarily limited, for no prevailing pestilential constitution of the general atmosphere of a district can be materially

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affected by them, whatever protection they may afford to individuals. Should future researches prove these, or any other physical agents, to have specific efficacy in checking the rise and propagation of febrile diseases, beyond what sanitary precautions are confidently expected to accomplish, a great desideratum will be attained; and, in the mean time, my own daily experience warrants me in viewing some of the proposed disinfectants as decidedly beneficial in, at the least, correcting nauseous smells, which I have already shewn to exert a baneful effect upon the nervous system. The difficulty I have hitherto always found in estimating their intrinsic value in checking the spread of typhus has arisen partly, perhaps, from not having experimented on a sufficiently wide scale, but chiefly that their employment has been contemporaneously associated with ventilating and other purifying measures, to which some portion of the attendant success might be fairly ascribed.

From a very early period the application of caloric with a view to destroy infecting particles, was much esteemed for its efficacy; and when we reflect on the ventilating properties of heat in altering the densities of the atmosphere, and thus establishing currents, (as will probably be fully explained to you this day in a subsequent paper), we are not surprised to find that the lighting of large fires in the narrow streets of old towns was a common practice in seasons of unusual pestilence. Heat, indeed, has more recently been suggested as having the power of decomposing the contagious principle; and analogies are not wanting in support of the proposition, for, *inter alia*, it has been found that the vaccine lymph is rendered incapable of communicating the cow-pox after exposure to a temperature so low even as 140° of Fahrenheit's scale. This fact accords well with my own theory as to an intimate connection subsisting between aqueous vapour and malarious atoms; for heat would

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probably dissipate the union, upon which their virulence and dissemination may depend. The numerous experiments of the late Dr. Henry with the flannel shirts of patients labouring under typhus, measles, and scarlatina, though not quite conclusive in support of his opinions, will perhaps be within the recollection of some of you now present. Dry heat has a great recommendation in its facility of application, without injury, to suspected articles of clothing and fabricated manufacture.

That by fumigation mischievous vapours might be decomposed and dispelled, has always been a very natural idea; and hence sundry aromatics, even, have occasionally enjoyed no mean share of popular approbation. Doubtless in thus disguising fætor, and in substituting an agreeable for an unpleasing smell, the resulting impression upon the nervous system is not to be despised in enabling the body to resist mephitic influences. The combustion of sulphur, the deflagration of nitre, and the explosion of gunpowder, have severally had their advocates, and the fumes of vinegar are still in repute. Muriatic acid had, as I think deservedly, a great continental fame; and the introduction of nitrous acid gas as a disinfector obtained for its fortunate patron, 50 years ago, a Parliamentary grant in this country. It is highly probable that the mineral acids, from their stimulant and corrosive properties upon organised textures, have some good effect on noxious effluvia of animal or vegetable origin; but except when sparingly impregnating an atmosphere, I do not think them so applicable where they are perhaps most wanted, viz. in inhabited apartments.

Quick lime, and its hydrate suspended in water as white-wash, has long and very properly possessed public confidence in promoting cleanly and wholesome dwelling-rooms. To be really useful, however, lime-washing should be repeated more frequently than is customary; for on its power as an absorb-

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ent, especially of carbonic acid, much of its chemical efficacy depends. In larger quantities lime has been much employed in correcting the disagreeable smell from cesspools.

Charcoal, too, is not destitute of virtue, and formed probably the base of Salomon's powder *noir animalisé*, as of the pastilles and water filters much used some years ago.

The preference over other disinfectants I have always given to chlorine has hitherto been undisturbed, although it has been my practice to make trials from time to time of newly recommended agents. Its ordinary evolution in the aëriform state, and its marked affinity for one of the elements of the most common and the most offensive of septic gases, and its applicability in the form of Labarrhague's liquid within the chambers of the sick, in my mind give it a pre-eminence over all its rivals. Although sulphuretted hydrogen, hydrosulphate of ammonia, carburetted hydrogen, and carbonic acid, be not really the matter of infection, these gases in towns are its frequent associates, and chlorine readily decomposes the three first, and, when combined as in this fluid with lime, is replaced by the last. Daily experience attests its efficacy in promptly correcting the stench of infected apartments, and its value in remedying the nuisance of bad odours in water-closets is familiar to you all. When properly used, it does not permanently leave its own peculiar smell for the original one which it removes. It does not act on the principle of a substitute disguising the first smell, but chemically to annihilate it. And the objection sometimes raised as to its employment in the wards of the sick is not valid; for except in some cases of disease affecting the respiratory organs, in which, as a disinfectant, it is less required, chlorine may, when suitably diluted, in all other instances be harmlessly inhaled. It is respirable in the preparation of bleaching powder, I understand, when present in the proportion of about 7 per cent.,

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though cases are said to have occurred both in the chemist's laboratory, and the works in which it is commercially manufactured, of fatal attacks of bronchitis having been induced from it. On the other hand, its dilute inhalation has been confidently recommended as restorative in pulmonary consumption; and in my own observation of its constant use, I have never in a single instance witnessed any bad effects.

As an antiseptic, Labarrhaque's solution is equally efficacious in purifying the tainted air extricated from soap-boiling, bone-crushing, tallow rendering, from drains, cabinets d'aissance, sewers, and night-chairs, and the like unwholesome sources of effluvium. Assuming chlorine to possess some specific power on malarious infecting matter, which my own experience would seem to justify, its action in this capacity may be supposed to reside in the decomposition of the associated aqueous vapour, for which it has a great affinity, with a resulting formation of chloric and hydrochloric acids, and an inert deposit of putrescent particles.

The preparation before you was made by simply passing chlorine through a saturated solution of fresh lime-water, with a little additional lime in suspension, and may be largely diluted for ordinary disinfecting purposes. The solution of chloride of soda is readily made by decomposing this fluid with the carbonate of soda, and possesses deodorant properties well suited for the dressing of sloughing and ulcerated surfaces, though in medical efficacy inferior in many cases, where an astringent is likewise wanted, to the diluted liquids of Ledoyen and Burnett.

The simplicity, efficiency, and inexpensive character of these chlorurets, when prepared on a large scale, give them a very strong recommendation; and were they sold at about one-third their present retail price, we might hope to introduce them into general use. There is, too, I see, advertised

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this month, a neat apparatus approved by the Pharmaceutical Society, to be had at 123, Newgate-street, for five shillings, whereby chlorine may be gradually but continuously evolved in a quantity sufficient to impregnate the air of a ten-roomed house for 24 hours at the cost of one penny. As this gas has double the density of atmospheric air, however, the second landing would, I think, be a preferable site for the generator, to the passage or entrance hall proposed by Mr. Smith.

The recommendation I have thus given of chlorine, in general terms, will not preclude us from entering upon a review of other disinfecting agents, and especially such as have of late obtained decided approval. These will be found all to consist of soluble salts with metallic bases. Of the whole group of them it may be safely affirmed that they unquestionably possess the property of decomposing those offensive effluvia in which sulphuretted hydrogen and the ammoniacal gases are the active ingredients; and had their respective patrons been content to rest their powers on this faculty until experience had tested their more extended claims, the discredit attachable to the undue puffing of any particular nostrum would undoubtedly have been obviated.

Siret's paste, consisting chiefly of the sulphate of zinc; Shalteman's sulphate of iron; Burnett's chloride of zinc; Ledoyen's and the unfortunate Calvert's nitrate of lead; Ellerman's persalt of iron; and Young's refuse manganese, have all stench-destroying agencies, and are also in a greater or less degree *antiseptic*,—a union of properties of no small advantage for disinfecting purposes. As already explained, it does not necessarily follow that such substances are antidotes to or corrective of a miasm-charged atmosphere or of disease-transmitting particles; although, as I have shewn, by neutralizing fœtor and thus preventing a depressing shock

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to the nervous system, their effect will be to diminish susceptibility to the absorption of malarious poison, and afford purity and freshness to the chambers of the sick. In this sense it is very possible they have some efficacy in the secondary causes of epidemic disease, by lessening its intensity and checking its spread when already generated. To accomplish these objects is no mean enterprise, and it remains for us very briefly and impartially to consider the claims of each, and to compare their relative value for some of the purposes assigned.

Were testimony to govern our decision, the efficacy of all these agents for all manner of ends upon organic and inorganic matters would be sufficiently attested, and the labour of selection superfluous; for they severally enjoy the sanction of names which, for weight of character and professional eminence, have seldom been surpassed. On the other hand, their introduction has, by some persons, very unjustly been condemned. But so long as we have excavations in back yards surmounted by high walls, the receptacles of all kinds of decomposing filth and garbage, steeping the ground itself with rottenness; so long as the cesspool system and the consequent nuisance of periodical removals of the night-soil is suffered to continue; so long as streets are built without reference to size, aspect, or inclination, and houses erected upon ill constructed drains; and so long as the present defective sewerage, exhaling a malarious atmosphere, engenders fever and lowers the general standard of the public health;—so long, I apprehend, we shall view with favour any means whereby the air may be purified, stench mitigated, and further putrefaction arrested.

I have had opportunities of repeated trials of nearly all these agents, more especially in reference to their anti-bromic or smell-destroying properties, not only separately but collectively; for by comparison alone can we hope to arrive at a

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sound conclusion as to that which is best entitled to our confidence for specific purposes. I have likewise tested the action of most of them when mixed with human excrement as manures to grass-plots; and should I abstain from tedious details of experiment, it must be ascribed to an unwillingness to trespass on your time and patience. Of Labarrhaque and Beaufoy's chloride of lime I have already spoken in its capacity of removing stench; and we will now shortly pursue the subject in respect to this quality in some of the others, and finally view their respective powers as antiseptics.

Taking them in the order of priority of application, Sir Wm. Burnett's fluid, I believe, claims our first notice, and will be found to be supported by a vast mass of evidence as collected in the pamphlet before you, printed by direction of the Board of Admiralty. It has been extensively employed in hospital wards and in ships, apparently with the best effects, as well as in the preservation from rot of timber and tackle, for which it was at first more especially proposed. In the letter addressed to me which I hold in my hand, the Hon. Gentleman gives further examples of the efficacy of the chloride of zinc in curing erysipelas, and arresting the spread of that disease, as it epidemically prevailed in September last at the Royal Marine Infirmary, and with equally successful results in cases of typhus in the Naval Hospital at Chatham. He then proceeds to extend its use to several affections of the skin, and suggests it as a remedial agent internally as a gargle in sore throat, in pulmonary hœmorrhage, chronic dysentery, and ulceration of the intestines.

To some of these objects the zinc, as an astringent, is doubtless applicable, and as such the sulphate of this metal is a pharmaceutical preparation in common use. As already stated, all the metallic solutions are disinfectors of putrescent effluvium, and of the power of this over the foul air and bilge water in crowded vessels we have ample proof afforded

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us. They decompose the sulphuretted hydrogen, and their liberated acid combines to form a fixed salt with any present ammonia. Their action on the septic gases is, I apprehend, very nearly alike in them all, in so far as two of the most offensively odorous of these gases are concerned; and we have no reason to suppose they exert any influence on the others, beyond the power these fluids possess as antiseptics to suspend further disengagement of them. The action between the zinc and the putrid gases referred to will be, that a portion of the neutral chloride will be decomposed, yielding, with the sulphuretted hydrogen, an insoluble sulphuret of zinc and hydrochloric acid; whilst with hydro-sulphate of ammonia, the other fœtid vapour, we have again a sulphuret of the metal and hydrochlorate of ammonia. It may be said in this case, in contradistinction to the other rival liquids, that a part only of the salt used would be decomposed; for so soon as the acid is in excess, or free, the further action upon any additional sulphuretted hydrogen present is suspended; and that the only insoluble product is the sulphuret, which, indeed, shortly by oxidation becomes itself a soluble sulphate. In reply to this objection it may be urged, that experiment shows the reaction to be such as to fix the sulphur and remove the smell, although the agent be not continuously, ad libitum, decomposed; and that though a larger quantity of the fluid may be required to accomplish a given work, yet that the object is attained. To the latter clause of the alleged objection little defence can be offered; for it does so happen that all the salts of zinc, except the carbonate, are soluble, and, pro tanto, pernicious to vegetation. Hence for the disinfection from stench of night-soil destined to agricultural purposes, Burnett's fluid is not well suited. All the other metallic salts, however, I believe to be open to this difficulty in a variable degree; and some of them, which are ordinarily recognised as insoluble, become otherwise when exposed to

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the vegetative process by intermixture with the soil. The oxide and sulphuret of iron, and the carbonate and sulphate of lead, as well as the soluble salts of zinc, when present in the proportion of about one per cent. of a dilute liquid manure of human excrement, I have found unfriendly to the health of blades of grass, which become brown in colour and curled towards their points; whilst there are no such effects when similarly treated with the alkaline salts, including those of magnesia and lime.

Burnett's fluid, in common with those of Ledoyen and Ellerman, has double the density of water, and is free from smell, which is a great advantage in the use of them. It is sold wholesale at 5s. a gallon, and is said to contain 200 grains of the salt to each ounce of the liquid.

During the sad prevalence of the late Irish fever, the preparation of Ledoyen and Calvert was much commended by high authorities, and apparently very successfully employed as a deodorising agent in the wards of the sick. The soluble salts of lead are assuredly proved to decompose and neutralize the prominent effluvia of decaying animal and vegetable matters, so as to produce inodorous compounds with them, or very nearly so. The resulting chemical action is almost identical with that of zinc, but a preference has been sought for this fluid, on the ground that the lead permanently assumes an insoluble form, and that the nitrate of ammonia is a more valuable fertilizer to the soil than the muriate. This view is, therefore, founded on the assumption that had the salt of lead, which is formed when mixed with animal manures, been in an otherwise than insoluble state, a noxious effect to the crops might be expected from soils dressed with this compost; but, as already observed, all the salts with metallic bases are more or less injurious to the vegetative process, a union being formed by the eliminating power of the vital functions of the plant, analogous to that which we find

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subsisting between the chemical composition of vegetable fibre, and the surrounding silica, carbon, lime, and other nearly insoluble earths. Such, at least, is the result I have arrived at by direct experiment, and such the interpretation I have ventured to build upon the fact.

Ellerman's deodorizing fluid, the base of which consists of a persalt of iron, is understood to be identical with that which Messrs. Dam, of Brussels, and Coutaret, of Paris, have recently patented on the continent. To render the removal of the privy drainage practicable without creating a nuisance, has been a desideratum with local authorities, and has led to the trial, on several occasions, of the respective merits of these liquids in accomplishing this object. The results of this competition, as might be supposed, are variously stated; but all accounts agree that they are effective in abating the stench when mixed with decomposing substances, and this is the point in which the public is most interested. In some of these instances, as though night soil and putrid blood were not sufficiently offensive, the phosphuret of calcium and the bisulphuret of carbon have been superadded to the mixture, so as effectually to test their disinfecting powers on decaying animal and vegetable refuse, and with the like conflicting measure of success, according to the testimony of the observers. In ships, workhouses, and naval hospitals, Burnett's fluid is most in favour; in the wards of civil hospitals that of Ledoyen has been much employed; the Poor Law Guardians of Hackney, and the *Pharmaceutical Journal*, seem to give the palm of superiority to Ellerman; and finally, whilst the Liverpool Health Committee take a Mr. Bromley's liquid by the hand, and Mr. Young strives to introduce manganese, the public generally, unconscious of their relative value, resort to Beaufoy as a household auxiliary when they want to get rid of a stench.

To enter into further details as to the uses of these various

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solutions for the purposes assigned would be to enlarge my paper to undue proportions, and I must therefore content myself with giving you, in very few words, the results of comparisons made by me of their respective virtues when similarly tested.

All the preparations, when suitably applied, greatly diminish fœtid exhalations, whether arising from the chambers of the sick, from privies, drains, and water-closets, or from decomposing animal muscle and bone; though none so perfectly in my experiments as does that of Labarrhaque, or Beaufoy's solution of lime. The habitual use of the lead leaves a grey crust on the pan or water-closet basin; there is less of this with the zinc, and none of it with the others. They all preserve the closet and house sink-drains sweet. With urine the lead precipitates a copious white deposit, and still leaves a strong smell of urea; there is less of this odour with zinc, and none at all when similarly treated with the lime. Except an instantaneous effect be desired, and the room unusually large, the hanging up of wet sheets in the wards of the sick to purify the tainted air is unnecessary with the lime, and a practice which might be objectionable to nurses and other attendants, from the diffusion of so much moisture into the atmosphere. The frequent mopping of the floors with the solutions is open to the same difficulty, and needless with that of Beaufoy. In fact, I prefer the liquid chloride of lime to any of the other proposed fluids, for the following principal reasons:—

1st. Because in infected apartments we have the noxious effluvia diffused throughout their limits in the gaseous form, a state similar to that in which the chlorine is evolved.

2nd. Because the atmosphere thus contaminated presents a more favourable medium to the prompt exercise of the marked affinities of chlorine for one of the elements of all the most common and the most offensive of the compound

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septic gases, all of which it decomposes, inclusive of carburetted and phosphuretted hydrogen, whilst the lime itself rapidly takes up the carbonic acid.

3rd. Because chlorine combines volume for volume with the hydrogen so as to form hydrochloric acid, with a density but little greater than that of common air, the action of which upon minute malarious putrid particles, if present, and upon their assumed vehicle, aqueous vapour, I have reason to believe is destructive of their power in the dissemination of the principles of contagious matter.

4th. That whilst the gradual extrication of chlorine, and its resulting compound gas, in an atmosphere charged with hydrogen, is very respirable in most cases, and those few in which its use might be objected to certainly not communicable diseases, the wetting of sheets with the liquid may be dispensed with as superfluous.

And lastly, because I find it relatively with the other fluids more effectual, and at a less pecuniary cost than some of them, in correcting the nuisance of bad odours, whether in chambers, in water-closets, or in urinary vessels.

We have here samples of some of the fluids in question; and of their relative efficacy in divesting night-soil of its stench, I shall give you an opportunity to judge from experiment, as the decision of the society will carry great weight with the public out of doors.

A claim has been set up on the part of Mr. Ellerman's preparation on its property of coagulating the semi-fluid night-soil, and converting it into a thick paste, so as to favour its collection and removal as a manure. But if intermixed with coal-ashes, this faculty, I apprehend, furnishes no available advantage; and if otherwise, the pumps made use of by the Metropolitan Commissioners of Sewers will more expeditiously cleanse cesspools, though assuredly at present to the entire loss of their fertilizing contents.

Assuming two per cent. of the concentrated solution to

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be severally required for the deodorizing of night-soil intended for agricultural purposes, my experiments would warrant me in giving the preference to the lime, and next to it the iron, as least detrimental to vegetation, and as the cheapest of the fluids when manufactured on a large scale. Those of Ledoyen and Burnett, however, may be applied to purposes for which the others are not well suited, as in the dressing of ulcers and sloughing sores, or in inhabited apartments, where the peculiar smell of chlorine is much disliked; and a further familiarity with their use will enable us wisely to discriminate their precise and more appropriate application.

Enough has been said, perhaps, to show that these disinfectants do really neutralize the most fœtid exhalations of decomposing animal matters, and that they may be advantageously employed as allies subsidiary to a general scheme of sanitary improvement. Until house drainage is perfected, they may serve to dispel the offensive mists which pollute the air of narrow streets and envelop the precincts of small tenements, but must not eventually be suffered to supersede the prompt removal of all impurities, or do the duty of the sewer, the scavenger, and the builder.

Finally, all these preparations unquestionably possess antiseptic powers, and as such will form a useful addition to those already better known. Unlike alcohol and the alkaline salts, which owe this property mainly to their having such an affinity for water as to extract it from moist animal tissues, their action depends upon a capacity of entering into combination with the component parts of the animal and vegetable organism to be preserved from decay, and to their forming permanent compounds with it. All the metallic salts, I believe, have this faculty, and the corrosive sublimate and the nitrate of silver, perhaps, in the most eminent degree. For the conservation of meat destined to domestic culinary use, however, it is important to select

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such as are harmless in themselves; and hence the liquid of Ledoyen I do not think adapted for this particular purpose. For the preservation of moist anatomical specimens it answers very well, but not for dried ones.

A discussion ensued, in which Messrs. HARDY and MORTON took part.

At the close of the meeting about twenty gentlemen, Members of the Society, retired to the Council-room, where ample preparations had been made in order to test the deodorizing powers of the several fluids referred to in the paper. Their *relative efficacy*, however, was the chief object aimed at, as being at once the most important to the public, and that upon which a decision thus deliberately expressed by the largest and most influential of the scientific societies of Yorkshire, might reasonably be expected to carry great weight with commissioners and parochial authorities, in the settlement of a question much agitated out of doors by rival claimants.

The materials operated upon consisted of given quantities of night-soil, fragments of horse flesh, and blood, in an advanced state of decomposition, which, together with a pail of lime from the gas works, charged with carburetted hydrogen and the bi-sulphuret of carbon, emitted odours which it is needless to describe. In instituting these experiments, the author of the paper regretted the absence, from indisposition, of his friend Mr. West, F.R.S., of Leeds, and of Mr. Denton, chemist, who had engaged to assist him in the necessary manipulation; whilst a third gentleman from Halifax, who had kindly tendered his services, was placed *hors de combat* from the stench. The experiments were conducted *seriatim*, when the opinion of the society was sought and expressed in each instance as they proceeded. For the present it will suffice to state that each and all the fluids in their turn mitigated the

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offensive smells. A division of sentiment prevailed as to the comparative merits of the liquids of Burnett and Ledoyen. Ellerman's preparation, likewise, met with favour, though some of the gentlemen present considered that under the disguised smell of pyroligneous acid, they could still sensibly perceive the fœtor of sulphuretted hydrogen. The air of the room and adjoining passage had now become excessively foul, these disinfectants appearing to exercise no action upon the general atmosphere, when the solution of the chloride of lime was made trial of as before, but with more striking and obvious results. The septic gases were promptly decomposed, and all stench removed. An unanimous opinion was declared, that the statements of the paper on this branch of the subject were fully confirmed, and that Labarrhaque's liquid was pre-eminently superior as a deodorant to any of the metallic solutions submitted to experiment. Additions of the chloride of lime were then made to the materials already acted upon by the other fluids, the effect of which was to complete that which had been previously only partially accomplished, and by scattering still more of it upon the floor, the air of the apartment was left very nearly, if not perfectly, sweet.

Mr. Ramsden, of Wakefield, read the second Paper,—

ON THE BEST MEANS OF DRAINING FIRE-DAMP FROM COAL MINES, BY AN IMPROVED PRINCIPLE OF VENTILATION.

After alluding to the importance of the subject, and the production of the safety-lamp by Sir Humphry Davy, which, however, had not answered all the purposes which its celebrated designer intended it should, he proceeded as follows:—

Having been an eye-witness to many of the calamities which have overtaken not a few of my ill-fated countrymen

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UNIV. OF MICH.

A SECTION OF AN IMPROVED SYSTEM OF VENTILATION FOR COAL MINES.

REFERENCE.

The Up-cast Shaft is shewn by	A	
The Down-cast " "	B	
Rise Galleries "	C	
The two small Shafts "	S	S
The Air Courses "	W	W
Two 5 Inch Boreholes "	V	V
The Furnace or Cupola "	U	U
The two Inclines "	X	X

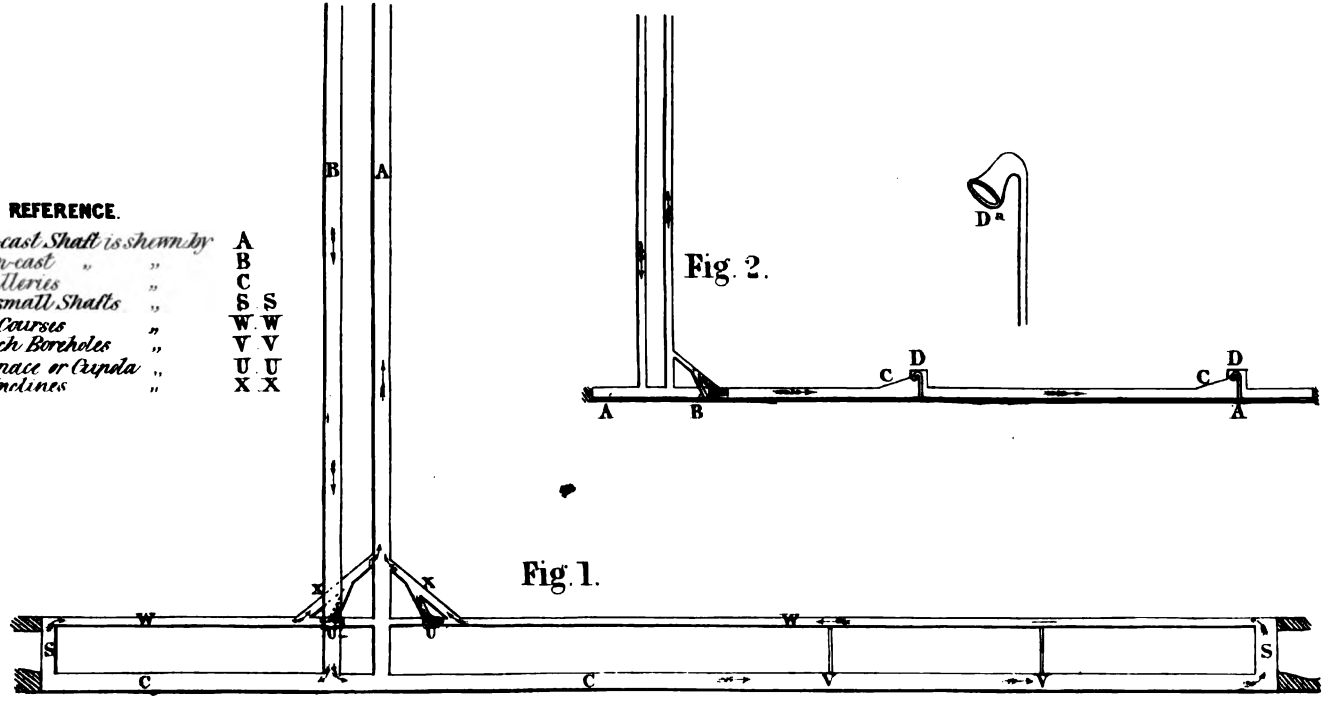

Fig. 1.

Fig. 2.

J. F. MASSER LITHO. LEEDS

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who were obliged to toil in the bowels of the earth for a scanty subsistence for themselves and families, I turned my attention to this subject, with a view to ascertain every cause of the frequent explosions in coal mines; and after much consideration and a series of experiments, I have been enabled to produce (what I think I shall prove to this Society) an unexceptionable remedy, and a certain and never-failing preventive of the so much and justly-dreaded explosions of coal mines, from fire-damp, &c., by admitting to every part of the most capacious mines a full current of pure air.

In a copious extract, entitled "An Exposition of the insecure Nature and Principles of the Davy and other Lamps, as applied to Coal Mining, taken from the Parliamentary Report for 1835," the subject is fully discussed; and in the evidence given by Dr. Murray, Lecturer on Chemistry, &c., as well as other scientific individuals present, it was their unanimous opinion that ventilation was the prime object. Yet there has not hitherto been any system of proper and efficient ventilation proposed, applicable to the numerous mines continually at work in this country. I shall endeavour, therefore,

1st. To call your attention to the improvement that I advance for the ventilation of the great Newcastle and northern collieries; and

2nd. To the principle which I consider applicable to existing mines in our own immediate neighbourhood.

PLATE XI., *Fig.* 1.

A refers to the upcast shaft.
B „ the downcast shaft.
C „ rise galleries.
S S „ two small shafts.
W W „ air-courses.
V V „ two five-inch bore-holes.
U U „ two furnaces.
X X „ two inclines.

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It must be obvious from the above section, that, to carry out the improvement, the air-courses, as shown on section, should be at an elevation from the workings, represented by the letters W W, with the furnaces at a convenient distance from the upcast shaft; also two inclines, as shown on the section, X X, at about forty-five degrees, so as to prevent the current coming into contact with the furnaces U U; the air-courses to be connected by two small shafts, as shown by the letters S S. I beg it to be understood that the air-courses, with small shafts, may be carried to any point that is most desirable, but always to be at the extent of the workings; and with reference to the present goafs, or where there is an accumulation of gas, it may be carried off by five-inch bores, as shown by the letters V V; so that the gas would always be carried off by the returning current along the air-courses, W W.

The advantage to be derived by air-courses above the workings, as shown on section (and which is applicable to all mines), is obvious, from the fact that any quantity of pure atmospheric air may be admitted into the works, and in direct currents to every workman in the mine, being returned at the head of the works, as shown on section, along the air-courses, W W, to the upcast shaft or compartment; so that there would be a constant current coursing the whole works, thus rendering an accumulation of gas in the mine an impossibility. It will be observed that, as the air descends the mine, the power given by the elevation of the furnaces and air-courses immediately circulates the whole, and it is carried off in advance of the workmen by the shaft and air-courses already referred to, without ever coming into contact with the workmen. The coal, as it becomes extracted, increasing the goafs or void, would always be drained of its gases by the circulating currents through the mine; consequently the fullest ventilation is secured, and may be extended

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to almost any distance, as the volume of fresh air introduced will be adequate to dilute and carry off all the carburetted hydrogen gas that might exude from the strata, so that it would be impossible for the mixture ever to reach an explosive point; for being carried off by such shafts S S, and air-course W, it would not take more than ten to fifteen minutes before being returned at the surface of the upcast shaft or compartment, even in the most extensive mines.

At present the air is traversing the works in currents and counter-currents, to the extent of from thirty to seventy miles, before being returned at the surface of the upcast shaft; which, at the ordinary rate the air travels, will take from ten to fifteen hours in performing its course, but leaving too often a great portion that it never reaches at all, as is ascertained in almost every instance where an explosion takes place. Besides, in the present system, there is no security for the workmen where even a partial explosion takes place, which is often the case from blowers, or the sudden fall of a portion of the roof, and attended with the most disastrous consequences in the destruction of life and property;—for instance, the Haswell explosion, the Darley Main Colliery, where six lives were lost; the Oaks or Ardsley, where the late dreadful calamity occurred; the Jarrem, and indeed in almost all other explosions which have taken place. When it is considered that dependence is placed on trap-doors, &c., for the current reaching the extremity of the mine, the consequence of the slightest interruption of the gateways may easily be imagined, and, as is evident, ventilation is deranged; and the air that should have been pure has reached the point of explosion, by having in its course come in contact with the accumulated gas. In such cases the unsuspecting workmen in different parts of the mine are not aware of their danger, but soon feel the effects, which are often fatal, even from a partial explosion.

It is a well-known fact, that from the effect of the back

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draught rushing down the shaft, which denotes the consumption of the vital air of the mine and the production of the deleterious choke-damp, the loss of life often exceeds that caused by the actual explosion. It therefore must be obvious that air-courses (constructed as shown on section) would be adequate to carry off all gases. With the current along the air-courses it is beyond the reach of human power to cause an explosion, and these air-courses may be constructed to meet any principle of workings, and to any degree; always having a proportional elevation from the works, with an incline from the cupola or furnace, as shown on section. It may be objected to as a matter of expenditure, but let it be fairly examined. It is well known that there are intermediate beds of coal, which, by getting, to form the air-courses and places for the furnaces or cupolas, with the incline, would more than pay the cost of driving; and allowing that it would only pay that expense, and taking the most unfavourable strata, (for instance, the Haswell or Jarrem), the expenses to be incurred would be in sinking the shaft at the extremity of the drifts, which, taken at an ordinary price, say £4 per yard, would amount to £150 or £200, which would carry the improvement into any of the northern mines. And again, consider the facilities that are given for working; the advantage it is to the workmen to have pure air instead of gas to consume; the extent of the mine (for the most extensive might be worked as well as the smallest); besides which there would not require half the doors or superintendence; so that I assume the improvement cannot be fairly objected to on account of expenditure.

When we look at the awful loss of life even in Jarrem, which, in twenty-eight years, amounted to 140, I should (as adverted to before) blow down from the drift sufficient of the roof to allow of boring a five-inch hole, or two, if necessary, to carry the gas from the present goafs.

Having brought before you, in as limited a form as I

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possibly could, so important a subject, I now leave it for your consideration; and will, in the next place, trespass a short time longer upon your indulgence, in bringing under notice the principle I wish to advance for the ventilation of mines in our more immediate neighbourhood, and in so doing I shall confine myself to the Oaks or Ardsley Main Colliery, near Barnsley, where the late dreadful explosion took place.

There will be observed on the plan of the mine alluded to (PLATE XI., *Fig.* 2) lines in the board-gates, which are shown in crimson; from these lines it must be understood that the principle will be applicable to any part of the mine, and may be carried to any point.

In commencing I would lay a drain, as shown on section in crimson lines (A), three bricks in height and one in breadth, covered with flag and mortar to keep air-tight; these are then laid and wrought in a funnel shape, to the incline flue of the furnace, as shown on section (B). This plan will be readily understood. At a distance from the shaft (say, when the air is likely to become charged to any extent, as will be observed on the section) blow down a cavity or receptacle, say three yards in height, with an incline to the wind (C); so that as the carburetted hydrogen gas, being so much lighter than the atmospheric air, is carried by it and comes in contact with the incline and elevation of the receptacle, the air would be again pure, and traverse its course onwards until brought into contact with another receptacle, which would again remove the gas from the air. Thus, according to the distance the air has to travel, and the gas in the mine, the cavities or receptacles would be formed. If the section is observed, a drain to each receptacle will be seen, composed of large drain tiles, which must be made and constructed so as to allow one end to overlap, say one inch, and to be secured with mortar instead of brick; and from the drain to each cavity or receptacle I should have eight or

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ten-inch wood pipes, with a funnel head turned downward (D and D a, enlarged view), to receive the carburetted gas. Thus would all the foul air of the mine be drawn by the furnace from the works, and from thence transmitted with the current to the surface.

I should like to say a word or two upon the goafs, but as it will be apparent to you that they may draw off the greatest part of the gas, if not the whole, on the same principle, so as to render the works safe, I shall desist; and observe that there certainly appears to me a great want of principle in the working of many mines which might be enumerated, even in this part of the country.

I therefore venture to hope that the necessity of sinking more shafts, in such districts as the Newcastle and northern collieries, would, in a great measure, be obviated by the introduction of air-courses connected with the works, as I have already explained; which air-courses and shafts, if brought into operation, will have, I presume, in a great measure, if not completely, equal power to shafts brought to the surface.

Finally, as the system I venture to suggest, if brought into general use, must eventually preserve the lives of thousands of our countrymen, it cannot be unworthy of the deepest consideration of the Society; and the fear, therefore, of incurring a little introductory expense should not deter our enlightened coal-owners from adopting the system now proposed.

Considering the great expenditure of the northern mines generally, the carrying of shaft after shaft from the surface would quickly involve an expense more than the value of the produce of the mine, and have the effect of closing the works altogether.

The Rev. William Thorp, B.A., next proceeded to describe the chief features of a New Safety Lamp, which

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was expected effectually to remedy all the defects of the lamp of Sir Humphry Davy, affording five times as much light, and being perfectly safe in every condition of coal mines. One of the principal defects to be obviated in the old Davy lamp consisted in its affording too little light,—and hence the temptation to miners to endeavour to gain an increase at any risk to themselves. While some frequently prefer to work with a candle, in constant danger, rather than use it, others are in the habit of removing the gauze to attain the same object; both of which expedients are well known to be fraught with the most disastrous consequences. In addition to which, the Davy is insecure, as well as all other lamps applied to coal mining, as proved by the Report of the Miners' Association of Newcastle, in 1835, furnished to the Parliamentary Committee.

Charles Morton, Esq., moved, and Thomas Wilson, Esq., seconded, "That the thanks of this Meeting be given to the gentlemen who have read Papers before the Society this day."

Henry Briggs, Esq., moved, and Dr. Wm. Alexander seconded, "That the thanks of the Meeting be given to the Vicar of Huddersfield, for his able services in the Chair."

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE THIRTY-SEVENTH MEETING, HELD IN THE PHILOSOPHICAL HALL, LEEDS, ON THURSDAY, SEPTEMBER 21ST, 1848.

In the absence of Earl FITZWILLIAM, President of the Society, on account of indisposition, the Rev. THEOPHILUS BARNES, Rector of Castleford, one of the Vice-Presidents, was called to the Chair.

The CHAIRMAN, after expressing regret at the absence of the Noble President, and its cause, and stating that a letter had been received from him excusing his attendance, said that the first subject which would be brought forward was a paper on the process of smelting iron with anthracite coal. It was a very great object in their Polytechnic, as well as Geological meetings, to look after the produce of the West Riding, amongst which iron was particularly important. He had been lately at Whitby, and there found that a new bed of iron-stone had been discovered upon the Whitby and Pickering Railway; and it was so favourable for putting on board ships and on the railway, that Dr. Scoresby told him his brother had an opening in a field, and that they wheeled the iron ore out into the trucks. This iron-stone was remarkable for the large quantity of shale which it contained, and this formed so large an amount of carbonaceous matter to smelt the iron, that it was taken from Whitby to Newcastle, and required very little more flux to be put into it.

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Iron, it was known, required a great heat to melt it, and this heat could not be so well applied to the iron ore as when there was a certain quantity of carbonate of lime within it. This carbonate of lime was supplied in very great quantity in the new iron-stone mine which had been discovered, and one great advantage of the discovery was the employment which it had created. Castleford people were engaged to take the ore to Newcastle, where they found coal, and there employed themselves and their vessels in whatever might turn out.

The following gentlemen were then elected Members of the Society:—

James Kitson, Esq., of Leeds;
G. E. Donisthorp, Esq., of Leeds;
Mr. William Ramsden, of Wakefield.

A Paper was then read—

ON THE PROCESS OF SMELTING IRON WITH ANTHRACITE COAL AND THE HOT BLAST; AND ON THE ADVANTAGEOUS USE MADE OF THE GASEOUS ESCAPE FROM THE BLAST FURNACES AT YSTALYFERA IRON WORKS, NEAR SWANSEA. BY W. S. WARD, ESQ., OF LEEDS.

The Paper was a recapitulation of the principal points in the communication of Mr. Budd, manager of the Ystalyfera Iron Works, made at the last meeting, at Swansea, of the British Association, with several additional observations by Mr. Ward, founded upon a careful personal examination of the works named. The original paper is about to be published at length in the *Transactions of the British Association*, and copious extracts from it have already appeared in the *Athenæum* and other newspapers. Mr. Ward stated that he was precluded from publishing his paper *in extenso*, lest it should injure the more elaborate communication of Mr. Budd in the *Transactions*; and as we have thus indicated to those who are interested in the matter where they may procure the

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fullest information upon the subject, we shall content ourselves with very briefly indicating the plan of Mr. Budd.

The ironmasters of Yorkshire are generally favourable to the cold blast process; and it has long been a reproach upon all engaged in the smelting of iron, that so much waste of combustible gas should be permitted at the top of their blast furnaces. Many attempts have been made to introduce the principle of heating the blast before it enters the furnace, by collecting the gas at the top of the furnace, and other contrivances—all, by the way, forming part of the furnace itself; but from some radical defect in each of them they were abandoned.

Mr. Budd, whose furnaces are fed by anthracite coal, found that to make fifty to sixty tons of iron weekly he consumed thirty-five tons of coal, and he therefore set about making a change in the process of smelting. He interfered in no way with the operations of the furnace; but he introduced three or four horizontal flues leading into the chamber or stove, which made the requisite draught, and procured as much gaseous escape as was necessary for the process of smelting. By a contrivance which it would be difficult to describe without the aid of a diagram, the combustible gases, which usually escape from the top of the blast furnace chimneys, fouling the air and destroying the chimney itself, are collected and re-conveyed to the boilers; so that the escaped gas from the furnaces is applied to the smelting of the iron. The advantages of this are numerous:—there is a great deal more iron smelted without additional coal or labour; the blast is better and more regular; the pipes, instead of continually wearing, and thus causing enormous expense, are rendered tough and durable; a furnace which had been stopped may be resumed in a few minutes; the saving in coal alone, if this invention were adopted throughout England and Wales, would be not less than £100,000

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a year; and if its use became general, the saving in fuel, materials, and labour, would amount to the enormous sum of £1,000,000 annually.

At the Ystalyfera works the escaped gas is made serviceable in the conversion of pig into malleable iron; and Mr. Budd considers it extremely probable that the fuel consumed in the blast furnaces will eventually be made available for all the other purposes of the works.

A brief discussion of a practical nature followed, in which the Chairman, Mr. West, Mr. Ward, and another gentleman took part.

The next Paper read was—

ON MALARIA AND DISINFECTANTS. BY JAMES HAYWOOD, ESQ., OF SHEFFIELD.

In applying the science of Chemistry to the explanation of the various natural phenomena with which we are surrounded,—in endeavouring to trace the manifestation of its changes in vegetable and animal life, and to discover the intricate decompositions which accompany these changes under the direction of vitality, is a task which has been left for modern chemists to prosecute and accomplish; and although the great cause by which these changes are effected is at present entirely hid from our comprehension, we have been able to acquire such an amount of knowledge of the effects, that we can now explain many of those vital transformations with a degree of certainty which cannot admit of a doubt. The chemical changes which take place in the stomach during digestion—many of those which occur in the blood during its passage through the system—the constant decomposition and re-formation of organised tissue in the body—is no longer a matter of speculation. The balance has even

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been applied in vital processes; and although it would appear at first sight almost incredible, we can now state positively to a few grains weight how much tissue is decomposed in a given time, and how much of the various kinds of food is required to restore it. With this amount of knowledge of the causes which pertain to the healthy existence of animal life, we have been led to investigate, and ultimately to comprehend, others of a more complex nature which influence its existence. The action of various foreign ingredients in the system, like the application of re-agents in analysis, were found to exercise a certain influence on the various compounds in the system, and to modify the changes on which a healthy action mainly depend. It is true that the action of many substances still remains a mystery; but from having perfectly made out the *modus operandi* of some, we may hope soon to discover that of the rest. The chemical change of organized tissue by the action of a corrosive poison, the chemical action of ammonia, alcohol, and other stimulants, and the influence of many organic salts, are all traceable to certain well-known affinities which these matters possess for certain substances with which they come in contact—affinities which we can demonstrate in our ordinary chemical operations, as well as prove to exist in the body. It is from facts and deductions such as these that I shall endeavour to trace out the cause of the apparently mysterious operations of malaria on the animal frame.

The existence of epidemic or infectious diseases in any locality—of a certain kind of fever, for instance, in places surrounded with cesspools, stagnant drains, or putrid marshes; of agues in damp undrained districts; or of cholera in filthy ill-ventilated dwellings—is of itself a sufficient proof that something is generated there capable of disturbing the ordinary healthy performance of some of the vital functions; and in endeavouring to discover this substance and to describe its

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nature, it will be necessary for me first to call your attention to a class of chemical phenomena which appears to me nearly related to those changes which are produced by malaria.

It is well known that the elements which enter into the composition of many mineral substances are held together by so feeble an affinity, that the slightest disturbing cause is capable of producing their separation. The force which binds together the elements of the fulminates of silver and mercury, of the iodides and chlorides of nitrogen, and the peroxide of hydrogen, is so feeble, that the slightest friction, in some instances even a draft of air, is capable of tearing them asunder. Organic compounds, and particularly those formed under the immediate direction of vitality, such as the constituents of the blood and secretions, being of a much more complex nature than any mineral compound, yield to influences even more slight than those just named, and give rise to new and simpler productions. The ordinary process of decay, in which the elements of all organized substances begin to form simpler compounds by uniting with the oxygen of the air when their vitality ceases, or of putrefaction, in which they form such compounds from a new arrangement amongst themselves, is a proof of the facility with which chemical changes are accomplished. No leaf or stem can lose its vitality without at the next moment producing new compounds by decay; nor can any animal substance, without previous chemical preparation, be prevented from undergoing the process of putrefaction. The compounds produced by the ordinary process of decay, namely, carbonic acid, water, ammonia, and nitric acid, are generally so simple in their nature and harmless in their properties, as scarcely to be considered injurious to animal life. The carbonic acid produced from the fallen leaves of a woodland district would so soon and so perfectly mix with the atmosphere, as not to render its presence in excess at all appreciable. Even in summer, that

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is, during the time decay goes on with the greatest rapidity, more than this excess of carbonic acid would be taken up by the leaves of plants during their rapid growth. In winter, when little carbonic acid is produced, in consequence of the process of decay being slow, all would be carried away in solution by the rains. In autumn only should we be likely to find a greater amount of this gas in extensive woodland districts than in the open country; but as this is not even found to increase the amount so much as to enable us with certainty to detect it, and can never be equal to that produced from the combustion of fuel in large manufacturing towns, we cannot assign any injurious tendency to its presence.

We must not, in fact, look to the natural process of decay for any thing prejudicial to the existence of life; it is a process ordained by an all-wise Providence to insure and maintain its existence. By it, dead and otherwise useless matters are converted into compounds useful in supporting the life of plants, and forming food for man; and by thus effecting a continued transmutation of matter from a state of death to life, it insures that uniformity in the earth's surface and in our atmosphere which appears so necessary to the existence of organized beings. It is a process, therefore, which, if allowed to go on with that regularity with which it was intended, and which does now go on in those healthy districts not yet over-crowded or polluted by the negligence of man, would still maintain the atmosphere in that uniform salutary state in which it formerly existed.

We must search among the products arising from those heaps of putrefying animal and vegetable remains, which, from being saturated with moisture, prevent all access of atmospheric air, and will not allow the natural process of decay to go on. Here we shall find not only compounds produced of an entirely different character to those generated by decay, but compounds the nature of which varies with

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every change of atmospheric temperature, pressure, and humidity.

Although putrefaction is commonly regarded as a simple process, generating substances the history of which is well known,—producing sulphuretted hydrogen, phosphuretted hydrogen, carbonic oxide, &c., yet I am convinced, from experiments recently made, that the number of new compounds formed during this process is much greater than is usually imagined. It is, indeed, impossible to conceive the removal of one atom of carbon, hydrogen, oxygen, or nitrogen from any organic product, without, at the same time, leaving a compound possessing a character entirely different from the original. As these elements are gradually removed atom by atom, or as they divide and subdivide, probably many times, before the last products are given off, I maintain that some of these intermediate compounds may be of a nature capable of producing, when conveyed into the system, disease or death. What is it that gives to the atmosphere in the neighbourhood of putrefying organic remains the various odours which characterise their presence? In many instances neither sulphuretted hydrogen nor phosphuretted hydrogen can be detected. It is not the simple odour of ammonia, nor of sulphuret of carbon; these compounds in many cases are absent. It is evidently some form of matter which has not yet been isolated, and the exact nature of which is certainly not understood. It is evident from this peculiar odour, which it generally, though not always, gives to the atmosphere, and more particularly from the deadly character which it invariably communicates to that fluid when present in quantity, that it is something capable of assuming the gaseous state, or of being dissolved in air, like other volatile fluids. Although it is impossible to detect any foreign substance in such air by the usual process of eudiometric analysis, yet when the air from the neighbourhood of stagnant drains is cooled below

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its dew point, the moisture which then separates appears to contain a volatile putrid substance in solution. By passing the air from any putrid source through a tube cooled by ice-cold water, I have been able to collect a considerable quantity of this solution; but as yet I have been unable to separate the active principle from the water and other compounds with which it appears to be associated, and consequently have not been able accurately to ascertain its composition or properties. I think, however, that I have made out satisfactorily that it is a compound of nitrogen, but certainly not ammonia or nitric acid; for on first ascertaining the amount of ammonia contained in a given quantity, and the absence of nitric acid or cyanogen, I found the quantity of ammonia very much increased by subjecting it to an organic analysis. At first I suspected it to be one of those volatile bases recently discovered in Dipel oil, but subsequent observation led me to conclude that such was not the case. That it is a substance capable of undergoing rapid decomposition is evident from its watery solution, at first perfectly transparent, but in a few hours after being collected becoming perfectly milky. In one instance a gas was evolved during its change, but I was not certain whether it might not have been condensed by the cold. I therefore consider it a nitrogenous organic compound in a state of rapid transformation—a substance, therefore, similar to yeast in many of its properties, and which, like yeast, is capable of communicating a similar state of transformation to many nitrogenous bodies with which it comes in contact. That this communication of *motion* or *change* to matter in a state of rest really takes place in numerous instances, is a fact so well understood by chemists, that I must apologise for introducing a few brief illustrations.

One of the most remarkable changes of this kind arises when amygdalin, one of the constituents of the bitter

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almond, and the kernels of stone fruits in general, comes in contact with emulsin, another substance which they invariably contain. On breaking the little cell walls, which, in the natural state of the fruit, kept these substances separated from each other, the contact of the two instantly causes the elements of the amygdalin to arrange themselves in new forms, so as to produce sugar, formic acid, oil of bitter almond, prussic acid, and water; and thus, from a substance perfectly harmless, are generated poisons of the most deadly kind. Another curious change is communicated to starch by the action of a peculiar principle, generated during the germination of seeds, called diastase. When so small a portion as one part of this substance is mixed with a solution containing one thousand parts of starch, and kept at a particular temperature, the whole is converted into a solution of sugar in the space of a few hours. In this case there is no exchange of elements between the diastase and starch, no more than between the constituents of the almond; it is the decomposing nitrogenous matters, namely, the emulsin and diastase, which, in both instances, suffice to induce the change. In the same manner when we add yeast, a substance in a state of rapid decomposition, to a solution of sugar, we find the elements of the sugar dividing themselves into two other compounds, namely, carbonic acid and alcohol, without in any way sharing the elements of the yeast. Other matters undergoing a similar kind of transformation to yeast are capable of inducing a similar state of decomposition to solutions of sugar; but if the kind of transformation, as I shall presently explain, be different, that is, if the compounds it is producing be not the same as those produced by yeast, we shall have a different kind of decomposition induced in the matters with which it comes in contact. The communication of putridity from one piece of dead flesh to another, or from one piece of wood to another, are all instances of

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decomposition from contact; and were we able so distinctly to see the state of the air in the neighbourhood of stagnant drains, &c., we should, on the same principle, be able to explain the reason why meats and other articles of food kept near to such places so soon become tainted. It inevitably arises from small portions of this putrefying compound being condensed by the moist surface of the flesh, and which causes it to undergo a change.

With these considerations before us, we shall now be able to form some conception of what really takes place when such substances are conveyed into the living animal system; for that a something, existing in the air of certain localities, entirely foreign to its natural constituent, must be conveyed into the lungs during respiration, is so clearly demonstrated by a number of facts as to amount to an absolute certainty; and that the introduction of matters into the blood in a state of putrefaction is capable of inducing a putrid state in some of the animal fluids, is evident from the dangerous and often fatal effects produced by dissection wounds. In this case the decomposition commences at the point where the poison was inserted, and extends, unless checked by timely aid, through the whole system. In some instances even the introduction of putrefying matters into the stomach has produced death. The poisonous sausages of Germany were found to contain no matters which, in an ordinary way, could be considered injurious to health, but were undergoing a peculiar kind of decomposition, which, being communicated to the system when taken as food, produced a wasting disease and ultimately death. The kind of decomposition induced in the latter case, or the kind of disease, is quite different to the former; they both arise from putrefaction, but the *modus operandi* of the change is different. Now, if the introduction of such poisonous matters directly into the blood, or even through the medium

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of the stomach, be sufficient to cause death, surely the constant application of noxious exudations from a similar source to the large surface of blood in the lungs, will be capable of engendering disease.

That the moisture condensed from the air of stagnant drains, &c., is sufficient to produce symptoms of putrid fever and death when introduced into the blood of a dog, has been proved by Dr. Southwood Smith, and stated by him in evidence on sanitary matters before a committee of the House of Commons; and I myself have verified his experiments on other small animals. I therefore believe that it is to this putrefying substance alone that we must look for the causes of all forms of infectious disease, and that it constitutes the various forms of malaria, miasms, &c., which are emitted from putrid marshes, stagnant drains, and accumulations of filth of every kind. That it is not sulphuretted hydrogen, or any of the ultimate products of putrefaction, I think is sufficiently proved by the fact, that persons who conduct processes in which these gases are continually disengaged, and who live in atmospheres highly charged, apparently suffer no more than persons who visit such places occasionally. These gases are no more capable of producing infectious disease in the human subject, than those which result ultimately from the decomposition of yeast are capable of producing fermentation in a solution of sugar, or those resulting from the decomposition of diastase or emulsin would produce the remarkable transmutation of the elements of starch or amygdalin. If, then, we regard infection as arising from certain decompositions of the animal fluids, induced by the presence of putrid particles dissolved in the respired air, we should naturally expect to find such diseases prevailing to the greatest extent in sheltered valleys or yards, where the air was stagnant, and where such matters were allowed to contaminate the air continually; and that such is really the case we have abundant evidence in the

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various sanitary reports which have been recently issued from the principal towns in the kingdom.

Having established the existence in atmospheric air of a substance in a state of rapid decomposition, capable of inducing disease when introduced into the animal frame, we will next endeavour to trace out the cause why disease, evidently produced from malaria, is capable of assuming various forms in different localities and at different seasons; and also the reason why stagnant drains, &c., should be a source of disease at one period and not at another.

We have already stated that the disease produced by decomposing sausages differs materially from that communicated from dissection wounds; and it would require a person to be very little versed in chemistry to see that the kind of decomposition going on in the sausages was entirely different from that in the putrid body. In the first the change is described as a slight softening, in which the mixture becomes lighter in colour, without the escape of any gas; whereas in the body considerable quantities of gas escape, and the substance becomes much darker. This difference in the kind of decomposition, which undoubtedly causes the difference in the character of disease, may arise from two causes; first, from a greater number of chemical compounds acting upon each other at the same time, or from a larger or smaller portion of moisture. We may, indeed, consider the presence of various quantities of moisture in organic compounds, or the degree of dilution of organic solutions, to be one of the principal causes which modifies the putrid decomposition of all organized bodies; for it is well known that when a certain amount of moisture is extracted from flesh, either by evaporation or the action of salt, this change is entirely arrested. We also know that the addition of a third substance to fermenting wort, namely, the bitter principle of the hop, has the effect of preventing the formation of an oily compound,

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which would be generated without it. The presence of many vegetable acids in the fermenting juice of the grape gives rise to volatile compounds, which produce the flavour and bouquet of wine, no such compound being produced by the simple fermentation of sugar (the addition of rennet to milk rapidly converts its sugar into lactic acid); hence we may safely infer that the various mixtures which are constantly occurring in our stagnant house-drains and cesspools, as well as the extent to which these matters are diluted with water, will, at one time, so far modify or alter their mode of transformation, as to produce compounds which are highly injurious to health, while at another they would be quite harmless. It is not in all states of putrefaction that matter introduced from dissection cuts is capable of producing dangerous symptoms; it is only when the putrefaction assumes a particular form that such is the case. The same thing may certainly occur with putrid drains, &c. We shall at all times find putrid matters present in the air contiguous to such drains, but the decomposition will not always be of such a character as to produce disease.

Perhaps the principal agent which modifies the process of putrefaction, and determines the manner in which the elements of compounds shall arrange themselves to form new products, is temperature. Nothing is more common in chemical operations than to produce one compound from a certain mixture at a low temperature, and another at a high one. In the case of yeast acting in a solution of sugar producing carbonic acid and alcohol, it is only below the temperature of 80° that this decomposition occurs. At a temperature between 80° and 100°, the transformation of the yeast and sugar is so far changed, that instead of carbonic acid and alcohol, we have lactic acid and gum. In the same manner we have the elements of sugar of milk at one temperature dividing themselves into alcohol and carbonic acid, at another into lactic acid, and at

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another into mannite and gum. If the putrid decomposition of such simple mixtures as sugar and yeast be so far altered by a few degrees of temperature as to produce compounds so widely different from each other as alcohol and lactic acid, how much more likely will it be to exercise a similar influence on the heterogeneous mixtures which constitute our undrained marshes or stagnant receptacles of filth? If we have poisonous matters produced from the decomposition of sugar at one temperature, and salutary ones at another, is it not reasonable to infer that such would be the case during the continuous and ever-varying changes which such matters are constantly undergoing? I do not think it improbable that the mode of decomposition in such matters may be altered by every change of temperature; hence we may have the same places at one time producing compounds comparatively harmless, and at another engendering the worst form of infectious disease.

That various kinds of epidemic disease are produced by contact with matters of a similar composition, although in a different state of change, is evident from the small pox virus, the matter of plague, &c. The remarkable manner in which such contagious matters reproduce themselves in the diseased subject would lead us to infer that if epidemic fever arose from the action of putrid malaria,—if it arose from a state of decomposition, communicated to the blood by *contact*, the *modus operandi* of its action would be precisely similar to that of contagious disease. We should have poisonous matters re-generated in the system, which would only differ from those of contagion by being volatile, and which would consequently infect the atmosphere by exudation from the lungs and skin. The reproduction of the exciting agent is well illustrated in the action of yeast in a glutinous solution of sugar, such as wort; and in this we have a neutral substance in solution, which, during the fermentation, is itself converted into yeast. I may say that the gluten here becomes

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converted into an infectious agent, capable of producing disease in a fresh portion of a solution of sugar, that is, of effecting its transformation. In the same manner I believe that during the continuance of all those diseases really arising from malaria, a fresh amount of exciting agents, similar in character to the one originally derived from the putrid source, is generated in the blood and other vital parts; and that it may spread from a diseased subject and produce a continuance of the malady in the same manner as it may radiate from a putrid drain.

I am aware that chemical and other experiments have been made, with a view to prove the non-existence of any matters in the air of rooms occupied by fever patients different from those naturally contained in the external atmosphere; yet the peculiar odour perceived in all such rooms might have convinced the experimentalist that something foreign was present, and that their conclusions were erroneous. It is not by a simple analysis of the air that we must expect to find these highly-rarefied compounds; it is only by searching for them in the moisture condensed from the atmosphere in contaminated localities that we can hope to discover their presence, and learn their properties; and I do not despair, if this course be pursued, of seeing all these matters exhibited in such a tangible form as will effectually clear up the mystery which has hitherto hung over them. I am aware that Queckete, and other eminent physiologists, would attribute the action of malaria, and, I believe, all infectious agencies, whether communicated through the air or by mere contact, to the presence of mycelium, a microscopic germ or spore, capable of reproducing itself with great rapidity, wherever it finds a suitable soil for its development. I am too well aware of the presence of such spores, and their rapid growth and re-production during the vinous fermentation, and of many other instances in the vegetable kingdom, entirely to

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discredit this hypothesis. There can be no doubt that as much mystery hung over the cause of the potato disease as over the phenomena of malaria; yet it is found to arise from a microscopic plant, whose habits appear to be similar to those producing mould or blight. The peculiar, and generally fatal disease induced in the human subject by eating rye bread, or using rye meal, containing portions of the ergot, has been clearly proved to arise from the rapid growth and extension of the mithelium, which produces the disease in the grain. It is true that the microscope has been directed in vain to discover these germs of fever in diseased subjects, and also in the putrid liquids condensed from infected air; but with our knowledge of the limits of the power of the microscope, we may conceive vital germs too minute for its reach; and consequently we must not altogether on this account discard an hypothesis which has certainly many important facts in its support. Probably the progress of the malignant cholera and some other epidemics could be much better explained on the mithelium hypothesis than on the putrefaction one; yet whether we believe it to arise from organic growth or decomposition, we must always bear in mind that the latter is invariably attended with the development of the former. In every drop of stagnant water —in every heap of decomposing rubbish, myriads of microscopic germs of life are developed and subsist; they find in it the food necessary for their growth, and the conditions necessary for their reproduction. It appears to me more rational to assign their existence to the peculiar state of the decomposing fluid, and not the state of the fluid to their existence. The various kinds of mould are only produced where they find the necessary conditions for their development. The yeast plant is not the cause of the decomposition of the yeast, but lives in consequence of its change. More than one microscopist has assigned the office of nature's

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scavengers to those microscopic animalculæ; and hence they would tend to diminish the amount of decomposing matters in the atmosphere, rather than increase it. We cannot, however, assign the same office to the various kinds of *mould, smut, or blight;* they will grow in the substance, and ultimately perfectly destroy the most healthy parts of plants, and even, in the case of the ergot of rye, will prey upon the vital structure of animals. If, therefore, epidemic disease is produced by the action of mithelium at all, it is produced by that of a similar character to mould and blight; but until we can see the germs of the disease, or are unable to find anything more likely to produce it, I think it more rational to adopt the theory—proved certainly to a certain extent, and established by the most conclusive facts—which assigns the phenomena of malaria to putrefactive decomposition.

Having now given a general outline of what appears to be the cause of epidemic disease in most instances, I will, in the next place, endeavour to point out those causes which appear to me most favourable for its generation and development. One of the most prominent causes calculated to produce disease, or render a large tract of country unhealthy, would arise from want of natural or artificial drainage. All vegetable and animal matters contained in a soil saturated with water, particularly those which, like peat-bogs and marshes, contain a large amount of such matters, will be in a constant state of putrefaction. The compounds produced in them, as in other mixtures, will depend on the temperature of the air, amount of moisture, &c., as above described. It would be almost impossible that from such sources, on some occasions, noxious matters would not be given off injurious to life. The position, however, of the undrained land, with respect to river courses, hills, and valleys, would very much modify its sanitary character. A marshy district, surrounded with hills, being protected from strong currents of air, and

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prevented from having its atmosphere frequently changed, would become more highly charged with the soluble constituents of the soil than those freely exposed to currents, which would constantly remove it. The condensation of moisture, in the form of mist or fog, appears to be highly favourable to the development, and to increase the intensity, of malaria. It would be likely to do so by repeatedly bringing portions into solution, and thereby increasing and maintaining their decomposition. I believe that the putrid matter, once condensed and allowed to go on putrefying for a time, would, when again dissolved in air, be more likely to reproduce itself in animal bodies than before. Hence it is that the currents of air which, on still nights, descend down the hill sides, and become cooled so much as to deposit a portion of their moisture, in the form of fog in the valleys, or on the course of a river, do not only tend immediately to produce the effects just described, but, by bringing effete matters from a distance and concentrating them on such points, materially increase the action of infectious agents. Valleys and river courses have not only been the prevailing localities of cholera, but of many of the most formidable maladies which afflict the human frame; while elevated situations, from being constantly exposed to change of air, and not liable to nightly fog condensations, would be less likely to suffer. Low sheltered localities in towns, such as those so often described by reporters on sanitary matters as centres from which radiate pestilence and poverty in its worst form, and of which we found not a few during our inspection of Sheffield, may be considered to represent small tracts in which infectious matters are constantly generated, and for want of a free circulation of air are allowed to accumulate, to the production of disease and death. The inhabitants of every closely built-up court or yard in low localities, where stagnant drains or heaps of decomposing animal matter are allowed to

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remain, are not only *liable* to become diseased, but are quite certain to suffer in health, more or less, from constant exposure. The habit of building most towns on the banks of some river or stream—done originally, no doubt, for the convenience of a supply of water, or for the transport of merchandise—has been the main cause that has rendered our principal towns so unhealthy, and our scale of average duration of life so low. There are certainly no means known at present calculated to obviate the evil entirely. Sheltered valleys and river courses will always be, from time to time, the scenes of stagnant atmospheres, fogs, and, to a greater or less extent, of a badly-drained soil. Towns in such localities must, at all times, be subject to the evils which attend such obvious sources of infection. A great deal, however, will depend on the nature of the soil on which the town is built, as well as on its exposure to these atmospheric influences. There are some soils so retentive of any liquid drainage which may soak into them, and so impervious to atmospheric air, that after a few years the whole surface acquires the condition of a putrid bog, while others are built upon a naturally or artificially porous surface, with a retentive clay subsoil, so that drainage can soak down, and convert the whole into a putrid mass, similar in condition to a stagnant pond partly filled with rubbish. In such cases it would be unnecessary for me to state that the results of putrefaction would be poured into the atmosphere in abundance. In some cases, however, the soil is sufficiently porous to allow all excess of moisture to drain away, and thus to leave the surface porous and permeable to the atmosphere. In such instances the process of putrefactive decomposition would be entirely prevented, and the healthy one of decay substituted in its stead. It is evident, therefore, that we should endeavour to imitate this natural process by artificial drainage as far as possible, for we should thereby prevent

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the formation and distribution of poisonous particles, as well as the consequences resulting from them. I consider, indeed, that the greatest improvement which could be effected in the sanitary condition of this country would be the one resulting from such a system of thorough drainage in towns as would not only carry off all refuse from the immediate vicinity of the habitations of man, but which would render the surface porous to a considerable depth: for I regard the disinfecting powers of atmospheric air as being very superior to any artificial agent we could employ, inasmuch as it will prevent the formation of miasms, although it cannot destroy them. In many instances we find soils containing oxydizing agents in large quantities, which, in some measure, impede the process of putrefaction for a time, and perform the same office as atmospheric air. The peroxide of iron, in the red sands of Sherwood Forest and the red clays beyond, loses a portion of its oxygen by contact with decomposing matter, and prevents the formation of hydrogen compounds, which would be produced without them. I consider the presence of peroxide of iron in a soil as a great natural disinfectant, and one which, so long as it lasts, is capable of contributing very much to the sanitary condition of the district. But still this is not sufficient, in our present system of drainage in crowded localities, entirely to prevent the production of disease; but it must tend to render districts where it abounds more healthy than those where it is absent.

I will now name another agent, naturally existing in the atmosphere, to which I would not have attached much importance had it not been generated at a time when it appears to be most needed,—I allude to the peculiar compound recently discovered by Schonbein, and which he named ozone. It is a powerful oxydizing agent, produced by the electric spark,—a flash of lightning, for instance, in its passage through air,—and consequently will be found in the atmo-

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sphere in large quantities during thunder storms. Now, as these storms generally occur in hot weather, when the air is more or less stagnant, and putrefaction goes on with the greatest rapidity, it would appear that they effected other important objects besides refreshing the soil. It certainly would tend to diminish the amount of putrid matters in the atmosphere. Schonbein has shown that atmospheric air very often contains this powerful agent; and he attributes all the phenomena of bleaching, and other forms of oxydiza tion, to its presence. If such really be the case, we should at once perceive that the air contained within itself the elements of its own purification; and certainly, judging from the beautiful manner in which all the phenomena of nature are adjusted for our good, nothing appearing in the least defective, we should be led to conclude that such is the case, whether arising from the action of ozone or not. In consequence, however, of men congregating together and forming crowded districts, there must always be places in which organic refuse, of greater or less extent, will accumulate, and pour forth its noxious exhalations in such quantity as cannot be immediately destroyed by the action of the atmosphere. We have already stated that the decomposing contents of cesspools, stagnant drains, and other refuse, have been at all times a source from which emanate disease and death; and although this may be remedied to a considerable extent by better constructed drains, an abundant supply of water, and other regulations, the evil will, to a considerable extent, remain in our villages and hamlets, if not in our corporate towns. It is for the purpose of defending the inhabitants of such places against the evils to which they are exposed, that we propose the use of some of those artificial disinfectants so well known to practical men.

It will be evident from what I have already stated, that the presence of some powerful oxydizing agent would be the

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most effectual means of destroying poisonous matters ready formed; while the addition of those commonly known by the name of antiseptics, would, by arresting putrefaction, be the most useful to prevent their formation. The action of the former depends on the facility with which they extract hydrogen from any organic compound, and thereby so far alter its composition as to destroy its former properties. Now, as we cannot very well conceive the existence of an organic product of putrefaction, similar to those which constitute the miasms of marshes, &c., to be free from hydrogen, it is clear that such agents are effective. Chlorine we may consider to be one of the most powerful oxydizing or dehydrating substances we possess, and as such it destroys organic colouring matter, or odours arising from sulphuretted hydrogen, phosphuretted hydrogen, and other products of putrefaction. It is best used in the state of chloride of lime, a small portion of which, dissolved in water, will, by absorbing carbonic acid from the air, liberate chlorine slowly and gradually, though in sufficient quantity to purify the atmosphere of apartments receiving the exhalations from such sources as those above named. The same substances, mixed with the contents of cesspools, &c., would, as long as any chlorine remained, prevent the liberation of any injurious compounds; but in consequence of this material being rather expensive, other oxydizing agents have been proposed, and employed with advantage in its stead. A person named Ellerman has recently patented a persalt of iron as a disinfecting agent, which certainly decomposes noxious gases, and will probably destroy the really injurious substances which accompany them, if applied in sufficient quantity. As long as any persalt of iron existed in a mass of organic matter, decomposition would be very much impeded, if not entirely stopped; while any injurious matters generated before its addition would be entirely destroyed. Nitric acid,

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produced in a state of vapour by pouring sulphuric acid on nitrate of soda or potash, placed on a heated plate, has been successfully employed in the wards of hospitals, &c. As a disinfectant it acts precisely in the same manner as chlorine, though probably with less energy. Nitrate of lead has also been recommended as a disinfectant for fluids, and, in consequence of its oxydizing tendencies, would probably be a very effective agent in destroying matters ready formed in the mixture, although I very much question whether it would arrest the progress of decomposition entirely. The expense, however, of procuring this agent will always be a prohibition to its general use. Any of these may be employed successfully, with very little precaution.*

There are other substances, however, whose mode of action, though not so well understood, is nevertheless of great importance, from the certainty with which they arrest the process of decomposition when mixed with organic fluids. Of this class are the various kinds of antiseptics, such as volatile oils, alcohol, coal and wood tar, and probably all their constituents, acetic acid, wood smoke, common salt, &c. The action of these matters is best seen when added to fermenting yeast or wort. If a single drop of creosote, or a small quantity of an essential oil, be added to yeast, it will immediately put a stop to the change it is undergoing, and prevent its communicating decomposition to a solution of sugar. The same thing takes place when these substances are added to flesh, or any nitrogenous organic compound. The common process of curing meat by smoking it with burning wood, in which creosote, &c., is generated, and of preserving animal specimens in alcohol or volatile oils, are instances of their preservative properties; and although this

* Since writing the above, I have ascertained that good chloride of lime contains four times the amount of available chlorine, and consequently will possess four times the disinfecting power, of Ellerman's fluid.

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is the first occasion in modern times that the subject has been brought forward,—in consequence of the great similarity between yeast and the matter producing epidemic disease, I would attach great importance to any substance as a disinfectant which would so completely destroy the action of the former. The old plan of boiling tar and burning brown paper in places charged with noxious exhalations, as a means of disinfecting them, would not be without its use; for in both cases creosote, &c., would be diffused through the atmosphere in sufficient quantity to produce a marked effect; and I have no doubt, were such plans adopted and kept up on an extensive scale in places exposed to epidemic disease, they would very much tend to prevent the extension of the malady. It will at once be evident that the action of these substances differs widely from those commonly known by the name of disinfectants; for while the latter are principally calculated to destroy poisonous matters, when once generated, by changing them into inert compounds, the former is destined to strike at once at the cause of the evil, and, by a specific action, to prevent their formation.

Having now given a brief outline of the nature of malaria, its mode of production and propagation, as well as the conditions of atmosphere and soil most favourable to its development, and the various natural and artificial agents calculated to destroy it, we may deduce the following conclusions:—

1. That the substance commonly called malaria is a nitrogenous organic compound, which, when dissolved in water or animal fluids, has similar properties to yeast, being in a continued state of decomposition, which state of decomposition it is capable of communicating to the fluids of the animal body.

2. That the character of the decomposition, and the variety of disease it will communicate, differs materially at various periods.

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3. That the sources from which the various kinds of malaria arise, are the decomposing animal and vegetable matters which are wholly or partly excluded from the free contact of atmospheric air; and that the kind of decomposition taking place under such circumstances depends on temperature and other causes.

4. That organic matters, freely exposed to the air and not saturated with water, will not produce compounds of the nature of malaria.

5. That the conditions necessary to prevent the formation of malaria are (in addition to a free access of atmospheric air) the same as those we should use to prevent putrefaction; and the means used to destroy it would be by the action of oxydizing agents and antiseptics.

A discussion followed, in which the Chairman, Mr. Haywood, Dr. Alexander, the Rev. W. Thorp, and Mr. W. S. Ward took part, and the obligations of the Society were expressed to Mr. Haywood for his valuable and opportune paper.

A Paper was then read—

ON A MECHANICAL COMMUNICATION FOR THE WORKING OF SIGNALS AND BREAKS ON RAILWAYS. BY WILLIAM SYKES WARD, ESQ., OF LEEDS.

Much attention has lately been paid to the effecting a communication between the engine drivers of railway trains and the guards in charge of the carriages; and also to provide means of communication between the passengers and the guards or engine drivers; but no method has yet been suggested so unobjectionable as to meet with general encouragement or support.

The directors of railways object to the expense of making

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any considerable changes in the present system of carriages, and also to the employment of any contrivances, the working of which would be dependent on the other carriages of the train being provided with corresponding apparatus; inasmuch as the transmission of carriages from one line of railway to another is so frequent, that on many of the great lines of narrow guage rails we seldom find a train which is composed of carriages all belonging to the same company, or of uniform construction.

Many engineers express a decided objection to allowing passengers any means of communicating with the driver, considering that more accidents and inconveniences might arise from the abuse of such power than would be prevented by its employment; but certainly there ought to be no objection to permitting passengers to communicate with the guard, who, after ascertaining the cause of alarm, might communicate with the driver.

Any means of communicating signals would be objectionable if subject to uncertainty of action, and particularly if any supposed signal might be accidentally given by the motion or oscillation of the train itself.

Signals given by whistles, or other means of producing sounds, may be perfectly audible to persons on any carriage following that on which such signal is given, but when the train is travelling very rapidly, the loudest sounds from the last carriage of a train are not easily heard by the engine driver.

The giving signals on railway trains by means of electricity is attended with many difficulties and sources of uncertainty. The currents which can be made practically available are slight, and are capable only of affecting delicate apparatus. If such currents are applied to produce the retention of a keeper to an electro-magnet, so that the signal be given by breaking the continuity of the circuit, the keeper is liable both to be permanently attracted so as not to detach itself

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when required, or it may detach itself by vibration; in the first case not giving a signal, in the second not giving a signal when required.

The exhibition of a flag or a light would afford an excellent means of communication if the attention of the party to receive the signal could be first obtained with certainty.

A simple mechanical contrivance for effecting a communication between the last carriage of the train and the engine, so as to ring a bell or communicate with a steam-whistle, perhaps affords the best means of attracting the attention of the driver, and is the most likely to be generally adopted if certain inconveniences be obviated.

It has been proposed to make a communication by means of a cord extended along the train. Such cord would be liable to require too much attention to its connexions or couplings when carriages are removed or added to the train; and if this objection were overcome, the lengthening and shortening of the train by the extension of the tug-rods and the compression of the buffers (amounting to ten, fifteen, or even twenty feet on a long train) might break the cord, give false signals, or, if the cord were very slack, prevent the giving a signal until a considerable length of cord had first been wound up.

It has occurred to me that the most perfect method of making communications on railway trains is by the circular motion of rods, extending under the carriages so as to form a system of shafting, which I call torsion-rods. This I propose to effect by means of rods moving in slides and having springs attached, so as to extend the rods in like manner as the buffers of the carriages; each set of rods having a portion in the centre capable of revolving on bearings attached to the framework of the carriage or carriage-wheels, and connected by universal joints with the sliding portion of the rods; and which revolves in, and is

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supported on bushes placed on springs, so as to give a little play both laterally and vertically. At each end of such system of rods is placed either an universal joint, capable of being attached to a similar joint, or a portion of a hollow cone, with a spike in the centre, and teeth or claws on its outer edge; so that two carriages on which the rods are applied being coupled together, such cones on the adjacent set of rods are pushed together, and will be held in contact by the springs, and form a coupling joint, capable of communicating circular motion from one set of rods to another; so that such rods will, when the carriages to which they are attached are coupled together, form a continuous line of shafting. Such system of torsion-rods will be extensible or compressible in length, and also yield laterally, according to the motion of the carriages; but will, when turned on their axes, communicate circular motion.

This may be more clearly understood by reference to PLATE X., *Fig.* 1, in which A represents the central portion of a shaft revolving in bushes B and B. C and C are universal joints, the construction of which is well known. D D and D D are rods on which the cross-pieces, E and E, slide, and to which are attached the rods F F, sliding into the necks G and G, revolving in the bushes at H and H. On the ends of the rods, F F, are placed hollow cones of metal at I and I, with teeth on the edges. Within the cones are spikes, K K, for the purpose of guiding the cones and teeth together, and which pass into the rod F, made hollow for the purpose.

In *Fig.* 2 is shown an enlarged view of two of the cones pushed together and shown as a section, so that the manner in which the spikes are intended to pass into the rods may be more fully seen. On the centre rod, A, (*Fig.* 1) is placed the grooved pulley, L. M M (*Fig.* 2) are springs formed of elastic bands of vulcanized India-rubber, which tend to

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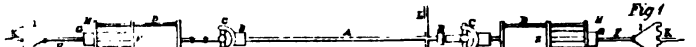

Fig 1

Fig 2

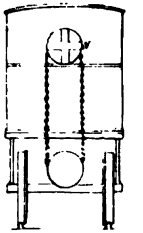

Fig 4

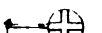

Fig 5

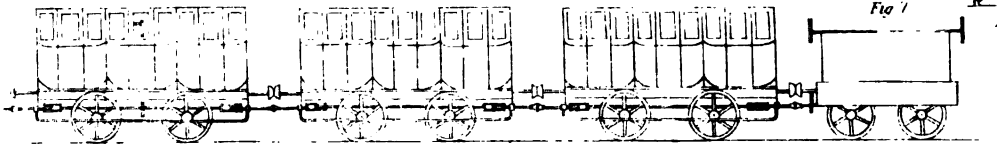

Fig 7

Fig 6

Fig 3

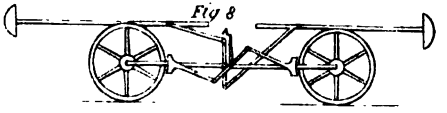

Fig 8

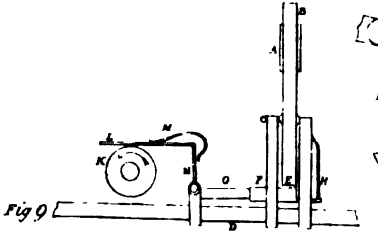

Fig 9

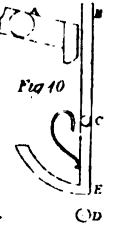

Fig 10

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force the ends of the rods outwards. The bushes are supported on springs, as shown in *Fig.* 3. The pulley, L, *Fig.* 1, is geared with another pulley in the interior of the carriage, as shown in *Fig.* 4, or on the tender. N represents a disc, painted so that its motion may be readily observed, and having a handle for the purpose of turning it round.

In *Fig.* 5 is shown an arrangement by which the gearing of the discs may be left moderately slack, so as to avoid friction when the same are only required to receive signals; and the bands may be considerably tightened by the guard giving additional pressure at A when he requires to communicate a signal, a spiral or other spring maintaining the ordinary pressure.

I have drawn the rods D E and F, in *Fig.* 1, in order that the principle may be easily understood. I, however, believe that in practice it will be advantageous to substitute a tube, of the form of which a section is shown in *Fig.* 6, in the interior of which the cross-piece, E, will slide.

I do not consider it necessary now to specify any series of signals, as it is obvious that by such torsion-rods the discs may be turned to the right or to the left continuously or interruptedly, so as to communicate a number of preconcerted signals; and catches may be added to the disc so as to set in motion an alarum, or strike a bell.

In *Fig.* 7 are represented some of the carriages of a railway train and a tender, showing the intended method of attachment.

I propose to apply the system of torsion-rods for communicating signals between the guards and engine-drivers of railway trains, affixing the rods under the carriages; so that the rods, forming a continuous shafting, may give simultaneous motion to discs or wheels placed in the guards' carriages, and also to similar discs placed upon the tender or engine, under the inspection of the driver; pulleys being fixed upon

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the central portions of the shafting under the carriages, to and from which communications are intended to be made; the pulleys being geared by elastic bands, with corresponding pulleys in the carriages, suitably placed for being turned by the guard or engine-driver, and also observed by him if motion be communicated from any other part of the train; thus affording the means of communicating a limited number of useful signals.

Such systems of torsion-rods might be attached to various parts of railway carriages, but for uniformity, and in a great measure to avoid injurious lateral motion, I prefer that such rods be placed centrically, and immediately above the axles of the wheels. The bearings or bushes of the rods may be attached to the carriages themselves, but as many railway carriages are constructed with framework connected with the bearings of the axles, I prefer attaching the bearings of the torsion-rods to such framework.

Whatever method of communicating signals on railway trains be adopted, little will be effected towards the prevention of accidents unless some efficient mode of quickly stopping the trains be also adopted.

When railway trains were seldom composed of more than five or six carriages, and the maximum speed was about twenty-five miles per hour, it was found that shutting off the steam and applying breaks to the tender was sufficient; but now, as railway trains consist of from ten to fifteen carriages, travelling at fifty miles per hour, the breaks on the tender and on the one carriage occupied by the guard are evidently insufficient.

Breaks, as applied to a single carriage, cannot probably be made to act much more efficiently than those at present used, and which are already capable of arresting the revolution of the wheels of the carriage, and making them act as a sledge on the rails. In fact, considerable care is required on

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the part of the breaksman to avoid this; for if the wheels be made to slide over the rails, a flat surface is formed, and the wheel is always liable to be stopped in the same position, so that the wheel rapidly becomes unserviceable by being so worn as to give a very uneasy motion to the carriage, and eventually is liable to jump off the rail.

An objection also arises to the applying very powerful breaks to the tender, and reversing the steam or applying breaks to the engine, that when the first part of the train is suddenly checked or retarded, the other carriages press forwards one on the other, having a tendency to throw some of the carriages off the rails, the train being as though squeezed together.

It therefore appears to me that the means of obtaining control over the speed of the train will be by increasing the number of breaks which can be brought into action simultaneously. Any method for effecting such purpose must, however, be simple, and must not require the employment of additional guards.

To effect this I propose to employ torsion-rods, similar to those I have already described, but made somewhat stronger, to communicate circular motion from one carriage to the adjoining carriages in the same train; so that the guard or breaksman may, in addition to working the breaks of the carriage on which he is riding, work breaks on the adjoining carriages; thus working breaks on three carriages, in lieu of working only one, as at present; and each of such breaks might be worked separately.

It has been proposed to connect the breaks with the buffers of railway carriages, so that when the buffer-springs are compressed the breaks will be brought into action against the wheels; and, in a long train furnished with such self-acting breaks, as each preceding carriage is pressed by the succeeding carriages, the buffers will put the breaks in action, and

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the train be quickly stopped. Such an arrangement occurred to me several years ago, but I saw the objection thereto, that the moving backwards a train provided with such breaks would be very inconvenient, unless some provision be made for disconnecting the breaks from the action of the buffers. The late Mr. Stephenson, at a meeting of civil engineers, at Birmingham, proposed a similar arrangement, but which has not been brought into use; I believe on account of the objection I have just alluded to, no provision being made for throwing the breaks out of gear simultaneously; it being necessary, according to his plan, that the breaks on each carriage should be thrown out of gear separately.

I have, however, proposed the application of torsion-rods, so as simultaneously to withdraw bolts or connecting pieces, and disconnect the breaks from the action of the buffers when it is required to do so.

If only a few carriages be supplied with such self-acting breaks the torsion-rods could very easily be applied; but if many breaks be used, and it is also required to use the torsion-rods for the purpose of giving signals, the requisite arrangement is not quite so simple. But I have devised an arrangement by which the torsion-rods may be used both for the purpose of communicating signals, and also putting the self-acting breaks in or out of action. The manner in which I propose to arrange such torsion-rods may be understood by reference to *Figs.* 8, 9, and 10, in which like letters are used.

Fig. 8 is a sketch of the buffers on one side of a railway carriage, for the purpose of showing a method of concentrating the action of the four buffers of a railway carriage on one piece, A.

In *Figs.* 9 and 10, A represents the last-mentioned piece acting upon the lever B E, which moves on a joint at C, upon two strong upright pieces fixed on the shaft D, and which communicates motion to the breaks. On the end of

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the lever is formed a small inclined plane at E, so as to push away the bolt, F, when the same is not prevented moving, as hereinafter mentioned. The said bolt, F, moves in a suitable hole or slot made through the uprights, and has connected with it the spring, H, for the purpose of bringing it back. The spring, I, *Fig.* 5, tends to return the lever, B E; which latter has a segmental arm, G, to prevent the bolt, F, passing behind it. K represents a pulley, placed upon the central part of the torsion-rods. L is a piece pressed upon the said pulley by the spring, M, and which serves to raise the catch, on the end of the crank or bent lever. The mode of action is as follows:—In the first place, if K be not turned previously to the buffers of the carriage to which such apparatus is applied being pressed in the piece, A presses on B, which, remaining firm, causes the breaks to be put in action. But if, by the torsion-rods, the pulley, K, be turned in the direction designated by the arrow, the catch is raised; and when the piece, A, presses on the lever, B E, the bolt, F, is forced out; consequently there is no action on the breaks. A spring should be also applied to keep the breaks, when not in action, from pressing on the wheels, but which, to avoid confusion, is not shown in the drawings.

I would suggest that, for the purpose of increasing the safety of railway travelling, all trains should be furnished with some means of communication between the guards and engine-drivers;

That the three carriages nearest the engine should be supplied with self-acting breaks; and

That the guard placed on the last carriage of the train have the means of working the breaks on the last three carriages, so that there would be six breaks to a train of ordinary length, instead of only one, as at present.

Mr. West (Mr. Barnes having been called away) then

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took the Chair, and briefly announced that the paper by the Rev. William Thorp, of Misson, their worthy Secretary, "On the Derbyshire Coal Field," would not then be read, as it was now time to adjourn for dinner. He was satisfied that Mr. Thorp would not feel disappointed at this, as, under the circumstances, the important paper he had proposed could not receive that attention which it demanded. With regard to the Evening Meeting announced, the Council had deemed it advisable not to hold it, as the paper of Mr. Thorp would not be sufficient to occupy their attention for an entire meeting. After stating that the next Meeting was intended to be held at Wakefield, the Chairman vacated his seat, and the proceedings terminated shortly after four o'clock.

END OF VOL. II.

EDWARD BAINES AND SONS, PRINTERS, LEEDS.

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SPECIFICATION OF THE PATENT

GRANTED TO

WILLIAM SYKES WARD,

OF LEEDS, IN THE COUNTY OF YORK, GENTLEMAN,

FOR

IMPROVEMENTS IN EXHAUSTING AIR FROM TUBES OR VESSELS FOR THE PURPOSE OF WORKING ATMOSPHERIC RAILWAYS, AND FOR OTHER PURPOSES.

SEALED JUNE 25, 1845.

WITH AN ENGRAVING.

To all to whom these presents shall come, &c., &c.—One part of my improvements relates to the arranging and working of the valves of air-pumps for the purpose of exhausting the air from the traction-tubes of atmospheric railways, and also for the purpose of exhausting air from any vessels or tubes upon a large scale. I will here remark that, in using air-pumps as hitherto practised for working atmospheric railways, power is lost in opening the inlet and outlet valves, by the action of the air entering into, and expelled from, the cylinder of the pump, and the violence with which such valves close is objectionable. Mechanical contrivances, or systems of gearing, have been used to work the valves of air-pumps; yet the methods hitherto employed or suggested for working the outlet valves of such air-pumps are either very complicated, or would fail in opening such outlet valves at the proper period of the stroke of the pump.

My method of constructing air-pumps is such, that the

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power required for opening and shutting the valves is supplied by gearing, or mechanical movements, from the engine, or other source of power by which the air-pump is actuated, so that the inlet valves are opened and shut alternately, almost immediately after the commencement of the stroke of the piston of the pump, and the outlet valves are respectively closed, or pushed home, at the end or conclusion of the stroke of the piston. The gearing afterwards releases the valve, which is retained on its seat by the pressure of the external air, until the air within the cylinder of the pump becomes nearly of the same density as the external air, when the valve (if the lower outlet) falls by its own weight, or (if the upper outlet) is raised by a counterpoise of greater weight than the valve, or by a spring, thus moving rather in advance, or as though in anticipation of the current of expelled air, and affording a free passage for it.

And, in order that this part of my invention may be fully understood, I refer to the annexed drawing or sheet, No. 1, though many different modifications of apparatus and machinery may be used to effect the like purpose, in which drawing, A, A, represents the cylinder of the pump, B, the piston, C, the piston-rod, D, D, D, pipes communicating between the main, or vessel to be exhausted, and the upper inlet valve-box, E, and the lower inlet valve-box, F. G, represents the upper inlet valve, and H, the lower inlet valve, which valves, G, and H, are attached to the rods, I, and I, at V, and V, by joints, allowing a slight motion, so that the valves may the better close on their respective seats. The rods, I, and I, move air tight, in stuffing-boxes, K, and K, and are moved, or worked, in suitable guides, by levers, L, L, furnished with suitable joints, and connected by the rod, T, T, part of which only is shown, with a suitable eccentric movement, but for which I prefer one of the eccentrics hereinafter more particularly described or mentioned, but which is not shown on the drawing now referred to. M, represents the upper outlet valve, and N, the lower outlet valve, respectively attached to the rods, O, and O, moving in suitable guides, and which valves, M, and N, may be respectively closed by the levers, P, and P, suitably fixed and acting upon the studs or tappets, Q, and Q, so as to close the valves, M, and N, alternately, but not to open them. The upper valve, M, is counterpoised, and some-

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what overweighted, by the lever, R, R, and the weight, S. The lower valve, N, opens by its own gravity, when not closed by the lower lever, P, or supported by the pressure of the atmosphere against a partial vacuum in the lower part of the cylinder, A, A. The levers, P, and P, are connected with an eccentric by the rod W, part of which only is shown.

The better to describe the operation or mode of action of the before-described air-pump, it must be supposed that the pump has already exhausted the main, or vessel connected therewith, to half vacuum, and is making the down stroke; the air from the main, therefore, enters at the upper valve, which was opened by the lever, L, immediately after the commencement of the down stroke, and the lower valve, H, was closed at the same time. The upper outlet valve, M, was closed simultaneously with the conclusion of the ascending stroke, and remains closed during the down stroke; and, at the same time, the end, P *a*, of the lower lever, P, released the stud, or tappet, Q, leaving the lower valve, N, at liberty to open by its gravity; but the air in the cylinder of the pump having had, at the commencement of the stroke, only half the density of the external air, the valve, N, will have been supported until the piston descended to about the middle of the stroke. The gravity of the valve, N, will then overcome the cohesion of its surface, and of the valve-seat, and open, leaving a free passage for the air to be expelled from the bottom of the cylinder. When the piston approaches the bottom of the cylinder, the valve, N, will begin to be raised by the lower lever, P, the motion of the piston, from its connexion with the crank of the engine actuating or driving it, will have become slower, so that the aperture will, nevertheless, be adequate for the expulsion of the air; but, at the turn of the stroke, the last-mentioned lever, P, will close the valve, N, quietly, so as to avoid any detrimental concussion consequent on the change of the stroke. The upper inlet valve, G, will be closed, and the lower inlet valve, H, will be opened. The upper outlet valve, M, will be left free, but, as before explained, will remain closed, until the density of the air above and below it are nearly equal, when it will be raised by the counterpoise, or weight, S.

I have, for the sake of greater perspicuity in drawing and description, described the pump as only having one

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inlet and one outlet valve at each end; but I prefer that, instead of each of the valves before described, more should be used; for example, three inlet and three outlet valves in the top of the cylinder, and three inlet and three outlet valves in the bottom of the cylinder.

Another part of my improvements consists in the combination of large vessels, or reservoirs, with air-pumps, so that such vessels, having been previously exhausted, shall assist the pumps in the exhaustion of the traction-tube, and that the steam-engine, or other motive power used to actuate the pumps, may be of much less power than would be required, if unassisted by the reservoirs, or that the traction tube may be exhausted with much greater rapidity than by the methods which have hitherto been used.

With respect to this second part of my improvements, I will remark, that reservoirs, previously exhausted, have been used in working experimental models of atmospheric railways, and have also been proposed as advantageous for the actual working of atmospheric railways; but such reservoirs were, or are, intended to be put into immediate communication with the traction tubes, by doing which considerable power is lost, as much more power is required to exhaust the residual than the first portions of air from any vessel, and such reservoirs would require to be exhausted to a much higher degree of rarefaction than would be by them produced in the traction-tube, and the air from the mains, which might otherwise be exhausted by a comparatively small power, would take the place of the portion of the air which had been exhausted from the reservoir by a very great expenditure of power. I combine pumps with reservoirs, so that one of the pumps which may have been used in exhausting the reservoirs may, by a slight change of its communication with the reservoirs, be employed as an air-engine, in order that the power exerted by the air passing from the traction-tubes to the reservoirs may be made effective in assisting the steam-engine, or other motive power, in working another pump; and also, that when the air in any of the reservoirs becomes of greater density than the air in the traction-tube, the air may be pumped from the traction-tube into such reservoir, with much less expenditure of power than in pumping from the traction-tube into the atmosphere.

I do not mean to confine myself to any precise or

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specific combination of apparatus to effect the before expressed purpose, inasmuch as my improvements may be differently combined and applied, according to the rapidity or rate of exhaustion required, and are applicable to any kind of vacuum reservoirs, whether exhausted by air-pumps by the withdrawing of water, or by the condensation of steam.

The manner in which I prefer to carry such purpose into effect is as follows:—

I construct large vessels, or reservoirs, of suitable materials. Such reservoirs or vessels may be of strong boiler-plate; but, for the sake of economy in construction, I prefer building the reservoirs of brick, or masonry, in a hemispherical shape, arched or vaulted, and supported internally with suitable arches and pillars. I then cover the external surface of such reservoir with thin sheets of iron zinc, or lead, well rivetted and cemented or soldered together, so that the masonry may render the structure sufficiently strong, and the sheet metal may render it air tight. Although the size and number of such reservoirs may be considerably varied, I prefer having three reservoirs, each of the like internal cubic capacity as the traction tube and connecting main, which such set of reservoirs is intended to assist in exhausting; and, although two such reservoirs will generally be found sufficient, yet I consider it more advisable to have three, in case of emergency, or unexpected leakage of the traction-tube.

I exhaust the before-described reservoirs by means of such air-pump as is partly delineated in drawing sheet, No. II., in which many immaterial parts are omitted to be drawn, for the sake of facility in delineation and description, and which pump I work by a steam-engine, connected with it in manner shown in sheets, No. IV., and No. V.

A, A, represents the cylinder of the pump, which, as regards the now describing apparatus must be of such dimensions as to be capable of restoring the exhaustion of the reservoirs in the interval between the running of the trains on the section of railroad it is required to work. And the steam engine, by which such pump is actuated, is to be of such power as to work the pump, and restore such exhaustion of the reservoirs with facility, in the before-stated period. B, represents the piston, C, the

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piston-rod, D, D, pipes leading to the air-tight boxes, E, and E, covering the inlet valves, F, and F, which valves are moved by rods G, G, connected by pins, H, H, with the said inlet valves. The rods, G, G, are moveable in their respective air-tight stuffing-boxes, I, I, and are moved by the combination of levers, K, K, and K, K, attached to the rods, G, G, at L, and L, and moving on centres, or joints, fixed to the top of the valve-boxes, or other firm support, at M, M. Such system of levers and valve-rods are actuated by the bars, N, N, and the lever, O, connected to an eccentric, as hereinafter described, or other suitable movement.

The pipes, P, P, lead to air-tight boxes, E^2, and E^2, covering the outlet valves, F^2, and F^2, moving in suitable guides (not shown in the drawing), and to which the rods, G^2, and G^2, are adapted, so as to close such outlet valves, but not to open them. The rods, G^2, and G^2, move in the air-tight stuffing-boxes, I^2, and I^2, and are respectively moved by the levers, K^2, K^2, and K^2, K^2, the set belonging to the upper outlet valve being actuated by the rod, R, and the lever, S, S, and the set belonging to the lower outlet valve being actuated by the rod, T, and the lever, U, U, and which levers, S, S, and U, U, are moved, at the proper period of the stroke of the piston, by the eccentric, as hereinafter described, or other suitable movements. W, represents a counterpoise, or weight, for raising the upper outlet valve.

Although, for the sake of facility of description, I have only drawn and described four valves in the pump, yet I prefer that twelve valves should be used, namely, three inlet and three outlet valves in the top of the cylinder, and three inlet and three outlet valves in the bottom of the cylinder, each of such valves having apparatus communicating such movement as herein described.

The upper outlet valves are to be counterpoised by weights, or springs, as hereinbefore described, with regard to the pump hereinbefore firstly described; but as, in the pump now under description, the outlet valves work within air-tight boxes, the counterpoises, or springs, for such upper outlet valves are to be placed within such boxes, or so as to communicate with such valves through air-tight stuffing-boxes.

I prefer working the inlet and outlet valves by the movement by extension, which is produced at the end of

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two levers when moved at the centre, because a very powerful, and, at the same time, accurate, movement, is given to the valve, which valve is also retained, or locked, upon its seat, until the movement is reversed, and this without any material strain upon the connecting-rods and eccentric movement.

I also prefer that the gearing of the valves be worked very promptly, and that after the valves are respectively opened or shut, the motion should remain what is termed dead until the motion is required to be reversed, and I effect this by a plate of metal, out of which is cut a space described by the intersection of two circles, as shown in fig. 1, sheet No. III., which is used for the inlet valves, which may all be moved by one eccentric being opened and shut at equal intervals,—that is, shortly after the change of the stroke of the piston.

Fig. 2, shows the form of the plate for moving the gearing of the upper outlet valves, and

Fig. 3, that for the lower outlet valves.

In figs. 4, 5, and 6, the eccentrics are represented in their places on their driving-shaft, and are referred to by the like letters and figures; A, representing the driving-shaft, B^1, B^2, and B^3, pulleys, or friction-rollers, working on centres attached to the pieces C, C, and C, which are bolted or screwed to the driving-shaft. D^1, D^2, and D^3, are the three plates represented separately in figs. 1, 2, and 3. E, E, and E, are pulleys, or friction-rollers, acting as guides to their respective plates. The distance from the acting circumference of the rollers, B, to the centre of the driving-shaft must be made equivalent to the semi-diameter of the circles by which the spaces in the plates, D, are set out. Therefore, when the driving-shaft carries round the rollers, B, as long as each travels in the segment of the circle corresponding to it, the plate remains at rest, but when the roller arrives at the other segment, the plate is moved until such segment corresponds with the arc described by the pulley, which then moves on, leaving the plate at rest until the pulley arrives at the other segment, the quantity of motion given by the eccentric being that between the centres of the two arcs of the respective openings in the plates, D^1, D^2, and D^3. With the plate fig. 1, the motions are at equal intervals, but with the plates figs. 2 and 3, in which the arcs of circles are of unequal lengths, the alternate motions are in unequal times.

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The operation of the pump, delineated in sheet No. II., is twofold: first, when the inlet-pipes, D, D, are in communication with a vessel, or reservoir, to be exhausted, and the pipes, P, P, in communication with the atmosphere, the operation is similar to that of the pump, delineated in sheet No. I., and hereinbefore particularly described, and to the description of which I therefore refer; and secondly, when the pipes D, D, are put in communication with the traction-tube, to be exhausted, and the pipes, P, P, in communication with the reservoir, previously exhausted, the air from the traction-tube cannot pass through the lower inlet-valve, F, which is held shut by its rod, G, and levers, K, K, but will enter into the upper part of the cylinder, A, A, by the upper inlet-valve, F, which is represented open; the air from the upper part of the cylinder cannot open the upper outlet-valve, F^2, which is held down by the rod, G^2, and the levers, K^2, K^2, but the lower outlet-valve being open, the lower part of the cylinder will be exhausted to the same degree as the reservoir; therefore the air from the traction-tube, pressing upon the piston, will cause it to descend, thus developing considerable power in aid of that of the steam-engine with which the pump is connected. When the piston descends to the bottom of the pump-cylinder, the lower outlet-valve is shut by the gearing, the stroke of the pump is then changed, the power to pass the centre being supplied by the fly-wheel, or by the steam-engine, the upper inlet-valve is immediately afterwards shut, and the lower inlet-valve opened simultaneously, the upper outlet-valve is then released, the air from the main enters by the lower inlet-valve, and the air from the upper part of the cylinder passes into the reservoir, and another stroke of the pump is made, and so on, the pump acting in aid of the engine until the air in the reservoir becomes nearly of the same density as that in the traction-tube, after which the pump will require power from the engine, but will require less power from it in pumping from the traction-tube into the reservoir than into the air, by so much as the air in the reservoir is less dense than the atmosphere. It must also be observed, that in order that the air from the traction-tube may not at any part of the stroke of the pump be enabled to enter the inlet-valve and pass out of the outlet-valve at the same end of the cylinder, without actuating the piston, the gearing of the outlet-valves must be moved

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at different times, as regards each other, and also as regards the inlet-valves, which will be found to be effected by the eccentrics, delineated in figs. 2 and 3, in sheet No. III., the longer arc in which must be set so as to correspond with the time during which its respective outlet-valve must be kept closed, and the shorter segment with the time such outlet-valve may be permitted to open.

In order to make the power given out by the lastly-described pump more fully available, I combine it with one or more other pumps, so that during the exhaustion of the traction-tube, pumps of a larger capacity may be worked than the power of the steam-engine, or other motive power employed, would suffice for: one of such combinations is shown in sheets No. IV. and No. V., of which sheets No. IV. is a partial elevation, and sheet No. V. a ground plan, the letters and figures upon which indicate similar parts, so far as the like parts are delineated in each plan. A, represents an air-pump constructed as lastly hereinbefore described, and of such size as to be worked with facility by the steam-engine, the cylinder of which is shown at C. B, is another air-pump, of similar construction to A. The pump, B, should be so much larger than A, that A, and B, shall together be sufficient to produce the required exhaustion of the traction-tube according to the speed desired to be given to a train, or the rate at which it is desired to exhaust the traction-tube. D, D, represents the main shaft of the engine, of which, D^2, is a continuation capable of being put into connexion with it by the clutch, E, and also of being disconnected whilst the engine is in motion. F, is the fly-wheel. G, the crank working the pump, A. H, the crank working the pump, B. I, and I^2, are the pipes in connexion with the inlet-valves of the pumps. K, a pipe leading from the inlet-pipe, I, of the pump, A, to the under part of the double way-cock, L, and communicating either with pipe, M, or the pipe, P, as may be required.

The double way-cocks, L, and S, are similar to the four way-cocks, Q, and R, which are represented in elevation on the upper part of the sheet No. V, and are constructed with hollow plugs, or stoppers, open at the bottom, and having an aperture at one side of the plug, that a large air way may be given with a moderate-sized cock; the upper parts of the cocks are rendered practically air tight by stuffing-boxes; a rod, adjustable by a screw, passes air

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tight through the plug of each cock, so that by bearing upon a plate at the bottom of the cock, and supporting the greater part of the weight of the plug, or stopper, the latter may be turned by a moderate power applied by the engine-driver at the capstan-formed-top, or by other suitable means. By the cocks, Q, and R, a communication may be made between the pipe entering the bottom of the cock and any one of the four ways. M, M, is a pipe in connexion with the main, or traction-tube. N, is a pipe leading from the pipe, O, in connexion with the outlet-valves of the pump, A, to the under part of the double way-cock, S, and so communicating either with the pipe, P, or the atmosphere through the aperture, V. P, is a pipe leading from the cocks, L, and S, to the lower part of cock, Q. T^1, and T^1, are pipes leading from the first of the three reservoirs hereinbefore mentioned, to cock, Q, and also to cock, R. The pipes, T^2, and T^2, respectively lead in like manner from the second and third reservoirs to the cocks, Q, and R. O^2, and O^2, are pipes from the outlet-valves of the pump, B, to the bottom of cock, R.

The operation of the lastly hereinbefore described apparatus is as follows:—The shafts, D, and D^2, being disconnected at the clutch, E, the pipe, K, being put in communication with the pipe, P, and also the pipe, N, with the atmosphere, through the cock, S, and the aperture, V, the pipe, P, being also put in communication with the pipe, T^1, by the cock, Q, the air-pump, A, being put in action by the steam-engine, C, the first reservoir will become exhausted, but such exhaustion need not be continued to a very high gauge; for example, the first reservoir may be exhausted until a barometer gauge attached thereto shows the height of about fifteen inches of mercury; by a change of position of the cock, Q, the second reservoir may then be exhausted to about twenty inches of its gauge, and lastly, by a further change of the cock, the third reservoir may be exhausted to about twenty-five inches of its gauge. I mention the gauges by way of illustration, and not for positive or even approximate direction; for the gauges at which it will be most advisable to work will evidently depend as well upon the size of the reservoirs as on a variety of other contingencies. The reservoirs being exhausted, the engine must be stopped, the shaft, D^2, and consequently the pump, B, put in connexion with the engine, the cock, L, turned so as to put

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the pipes, K, and M, into communication, and the cock, S, turned so as to put the pipes, N, and P, into communication, and close the aperture, V, the cock, Q, turned to put pipe, P, in communication with the atmosphere through the aperture, X, also the cock, R, must put O^2, in communication with Y. The signal being given to exhaust the traction-tube, the engine will be again put in motion and both the pumps put in action, the engine being sufficiently powerful to exhaust the tube to the lower numbers of the barometer gauge, but will soon become unequal to continue the exhaustion, but the cock, Q, being turned one quarter round, so as to put P, in communication with T^1, the vacuum in the first reservoir will then not only relieve the engine of the resistance of pump, A, but will aid in working pump, B. Afterwards, as the exhaustion of the traction-tube increases, and that of the first reservoir decreases, such aid will become insufficient; the cock, R, may then be moved one quarter turn, putting O^2, in communication with the first reservoir; the power of engine being then in excess, Q, may be turned back, connecting P, with the atmosphere; after a few strokes, turned again to T^1, afterward to T^2, then R, may be turned to T^2, Q, back to T^1, again to T^2, and then to T^3, when the exhaustion should be complete, the train being passed, and leaving a considerable degree of exhaustion in the third reservoir ready for any contingency. The train being passed, the exhaustion of the reservoir, diminished by the before-described action, is to be restored by the engine and pump, A, as hereinbefore directed.

Another part of my improvements consists in the construction of the pistons of large air-pumps, regarding which I will remark, that the pistons of small air-pumps are generally packed with leather, sometimes with strong leather cut or turned to fit the cylinder of the pump, and sometimes with leather so arranged that the leather forms a cup or concavity in the direction in which the air would tend to pass by the piston; but these methods do not provide any sufficient adjustment of the leather packing after it becomes worn, nor would such packings work at all times so far air-tight as desirable without considerable friction being produced. To obviate, as far as possible, these defects, and, at the same time, to avoid the friction and expense attendant on the use of metallic pistons, I pack the pistons of air-pumps with leather cut into bands,

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or straps, of the breadth of about one-sixth part of the diameter of the cylinder of the pump. I prefer leather of ox-hide, such as is used for straps for working machinery. Such bands are united by sewing, and also with the well-known cement of isinglass or fish-glue dissolved in weak spirit, or are united by other suitable means, so as to form a continuous circle of about the same diameter as the pump cylinder, but considerably conical, so as to facilitate the bending hereinafter mentioned. The bands of leather, after being softened by water and placed upon a block of similar size to the piston, are then bent and contracted so that about one-third part of the breadth may fit the cylinder and the other two-third parts may be attached to the piston, and secured by plates of metal screwed to the main part of the piston, but which screws being slightly loosened would allow the leather to be driven outwards, or towards the sides of the cylinder, after a portion of the said packing has become worn. The shaving off the hair side of the leather will much facilitate the forming it into the required shape, and also the cutting out gaps or notches where the screws or bolts will be required to pass. After the leathers are put into the required form, they should be well saturated with neat's-foot oil, or similar unctuous matter. The edge of the leather band being thus turned will form a portion of concave surface which, being well supplied with oil or other suitable lubricating matter, will fit for the cylinder so as to be air-tight, and yet move with very little friction. Although it is well known that the leathers of the pistons of pumps constructed in a similar manner to that hereinbefore described, become the tighter the greater the pressure they are exposed to, yet the packing of the piston of a large air-pump must either be made somewhat more tight than advantageous, or when the pressure of the air on which it is acting is slight, the air will be liable to pass before the leather expands so as to fit the side of the cylinder. I therefore insert a series of springs, formed by cutting gaps or notches in plates of very thin steel, similar to what is manufactured for making steel pens, forming the segments of a circle, and then bending the parts left to a similar form with relative portions of the bands of leather hereinbefore described, so that the springs, after being tempered, may be inserted between the band of leather and the plates which fix it on the

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piston, the springs being first rivetted on such plates. I construct and pack the upper and under sides of the piston in a respectively similar manner. The construction and packing of the piston will be more readily understood by the drawing or plan, sheet No. III., figures 7, and 8, in which A, represents the main portion of the piston, which may be of cast iron; B, B, the continuous bands of leather; C, C, C, C, the plates by which the leather is fixed on the piston by a convenient number of screws, or screw-bolts, *d*, *d*, *d*; E, fig. 8, represents the plate of thin steel after being cut for forming the springs, and F, the same plate after the springs have been bent upwards; such springs are rivetted to the plates, C, C, and are shown in position at G, G, G. The smaller plates, H, H, H, are removable independently of the plates, C, C, C, C, in order to permit the insertion of a suitable bent tool or tools for the purpose of forcing out the band of leather when partly worn so as to present a fresh surface to the cylinder, the space left by the leather being afterwards filled up with pieces of wood, or other suitable material, so as not to leave any undue space for air.

First, I claim the so arranging apparatus or gearing with the valves of air-pumps, as to close the outlet valves but not to open them, the gearing leaving such valves at liberty to open when relieved from the pressure of the air.

Secondly, I claim the so combining vessels or reservoirs with air-pumps in working atmospheric railways that the air may be pumped from the traction-tubes of atmospheric railways into partially exhausted vessels or reservoirs, and, when desired, the pressure of the air passing from such traction-tubes into such partially exhausted vessels or reservoirs may be used for giving motion to air-pumps.

Thirdly, I claim the mode of packing pistons of air-pumps as herein described.—In witness, &c.

WILLIAM SYKES WARD.

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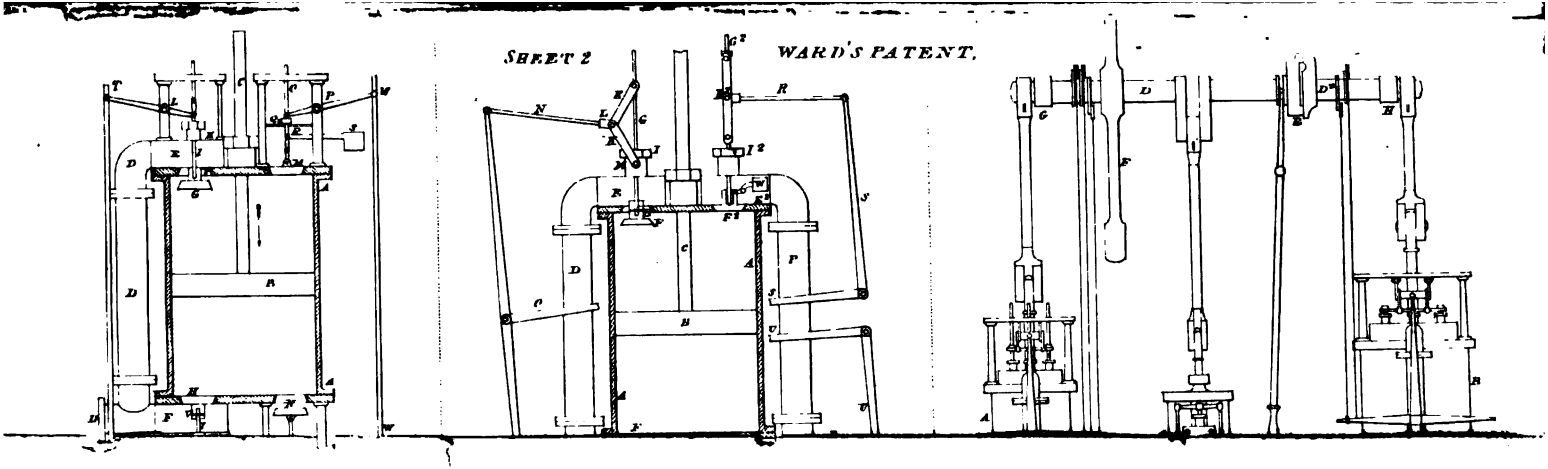

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